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ONTARIO HYDRO
RESEARCH ANNUAL





From its modest beginning three-quarters of a century ago, the Research Division has grown to be a vital part of Ontario Hydro. Not satisfied with just peering through windows, Hydro researchers have, since 1912, continually endeavoured to make Ontario Hydro a world leader in electric utility research.

The front cover shows a scene from an early standards laboratory, such as was set up by Ontario Hydro circa 1916. The view through the window contrasts the precision instruments of this era with the technology of the 1980s used by Hydro in support of its nuclear generation.

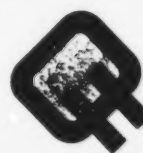
A selection of significant research contributions made during the past seventy-five years is shown on the inside back cover. As always, Ontario Hydro strives for excellence in service to its customers through the talents and commitment of its people and the wise use of modern technology and practices.

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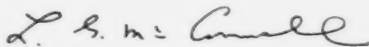
VICE-PRESIDENT'S MESSAGE

Nineteen eighty-seven marked the 75th Anniversary of the inception of laboratory research at Ontario Hydro. This makes Ontario Hydro's Research Division the oldest utility research organization in North America. The Research Division has, over the years, established a world wide reputation for innovation and leadership in electric utility research.

Throughout its history, the Division has developed many new techniques and instruments that have been adopted by others. For example, the Soniscope, an instrument developed in the 1950s to inspect large concrete masses by means of ultrasonics, is being used around the world. The Soniscope is not the only development, and a brief description of the Research Division's history of accomplishment is given in the supplement at the back of this year's report.

Ontario Hydro has always been concerned with helping its customers to make good use of electricity. In fact, right from its beginnings, the Research Division was involved in testing and evaluating electrical products and setting standards for their manufacture and application. As well, Ontario's manufacturers have used information generated by Hydro's research to improve the quality and competitiveness of their products.

I congratulate the management and staff of the Research Division on the completion of seventy-five years of outstanding contributions to Ontario Hydro and to the power consumers of Ontario.



L.G. McConnell
Vice-President
Power System Program



Lorne McConnell holds a klydonograph, a device developed at the Research Division to record lightning-produced voltage surges on transmission lines.

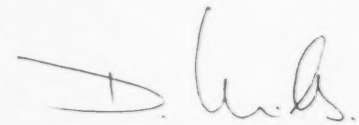
This year marked the seventy-fifth that research and development has been an integral part of the Corporation's work program. Throughout its history, the Division has been responsible for meeting Ontario Hydro's current technological needs. In recent years, because of rapid technological growth and change, increased emphasis has been placed on anticipating the Corporation's future technical requirements.

Coupled with increased pressure to keep pace with scientific advances is the need for new technologies to deal with social and economic concerns. For example, current interest in environmental issues has resulted in

a concomitant increase in related research activity. Although the Corporation has always tried to minimize the impact of its operations on the environment, more information about the effects of power system operation on the environment and better methods to mitigate these impacts are required. The Division's current work includes such activities as the investigation of options for controlling acid-gas emissions; research into the transport, transformation, and deposition of pollutants; and novel concepts of vegetation control in transmission corridors. The Division has also achieved world recognition for its use of behavioural

techniques to minimize the impingement of fish at generating stations.

Environmental research is of course only one of the Division's ten programs. As in the past, Research staff are today providing technical support for the Corporation which will help ensure a reliable and inexpensive supply of electricity in the future.



Don Mills
Director
Research Division



Don Mills visits an environmental monitoring installation at Trafalgar TS.

Manager's Report

The Chemical Research Department has approximately 70 scientists and engineers and an equal number of technical and support staff who work mainly in the chemical, biological, and environmental disciplines. The Department's research and development program in support of the Corporation's needs is comprehensive, ranging from long-term scientific investigations and short-term problem-solving, to provision of chemical analytic services.

In 1987, research in the nuclear and environmental areas constituted the largest components of the Department's work, each area representing approximately one-third of the total \$12 million dollar program.

In the nuclear area, numerous projects were carried out in materials development, reactor component



Inspection of generator No. 2 at Ontario Power Generating Station in 1905.

integrity, and in chemical process development, which contributed to the continued reliable and safe operation of Ontario Hydro's CANDU reactors and to the repair and maintenance activities associated with reactor retubing.

In the environmental field, major efforts continued in developing methods for controlling acid-gas emissions from coal-fired stations and in establishing their environmental pathways. Biological surveys were carried out to determine the impact of Ontario Hydro's generating facilities on the environment.

A number of long-term programs saw commercial application this year. The development, in conjunction with CFFTP, of a chromatographic system for separating hydrogen isotopes for fusion facilities was completed, and the system was sold to the Karlsruhe

Tritium Laboratory in West Germany.

The process for polychlorinated biphenyl (PCB) destruction, which was developed jointly by the department and BC Hydro and licensed to an Ontario-based company, operated successfully both outside the province and within Ontario Hydro to decontaminate 150,000 litres of PCB-contaminated oil. An acoustical device for controlling fish movement at intake structures successfully proved its effectiveness at various locations, and negotiations are currently underway to transfer this technology.

The Chemical Department is divided into five sections with responsibilities in the areas of process chemistry, materials, analytic chemistry, biology, and environmental science. In addition, the Department has a project group working in the area of corrosion chemistry. The Department also has

CHEMICAL

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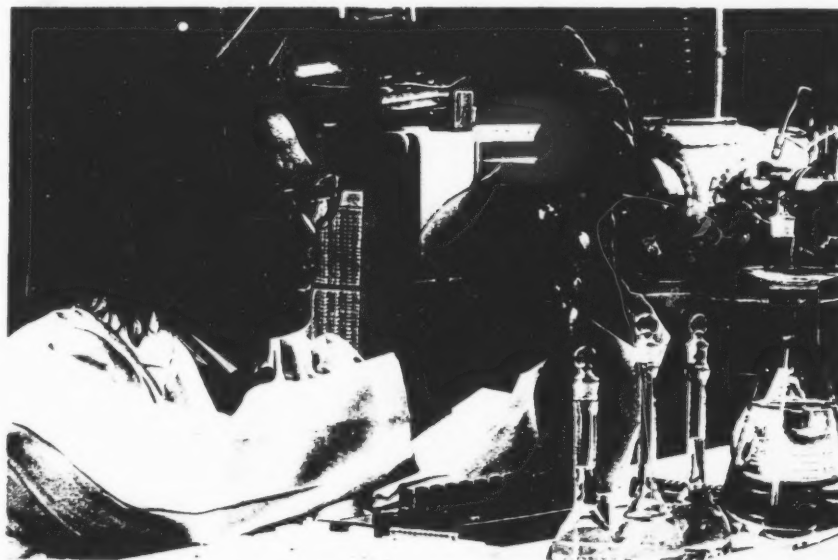
Mr. O.T. Melo

Materials Chemistry

Dr. R.W. Glass

Process Chemistry

Mr. D.J. Dodd



Extracts of water samples are being prepared for analysis on a gas chromatograph/mass spectrometer that can detect and identify trace quantities of organic compounds in environmental samples. The technician is shown taking a small sub-sample for subsequent injection into the instrument.

two senior research scientists who are involved in projects on prawn aquaculture, on the biological effects of electromagnetic fields, and on the quality assurance of radioactive waste forms.

Technology is being developed for the thermal aquaculture of giant freshwater prawn. The successful demonstration of this technology is expected to create a significant market for waste heat and steam, and in some cases, electricity. Substantial progress towards this goal was made in 1987. The objective in 1988 is to firmly establish commercial interest in this technology.

Since the 1980s, public concern about the possible health effects of electromagnetic fields has increased. As part of a broad Corporate program to address this issue, a study has been proposed to test the hypothesis that exposure to 60-Hz fields may increase the activity of carcinogens.

The management of operating wastes from Ontario Hydro's nuclear reactors requires that packages of radioactive waste have acceptable integrity and no flaws. The development of methods for assessing the quality assurance of radioactive waste forms was started in 1987 and constitutes Ontario Hydro's component of an effort coordinated by the International Atomic Energy Agency (IAEA).

Analytic Services

The Analytic Services Section supports the research of scientists across the division by providing advice, state-of-the-art instrumentation, and chemical analytic services. Scientists consult with analysts to work out the best experimental designs to ensure that chemical analysis of samples will provide them with optimal data. Analysts maintain the existing analytic capability of the laboratory and develop new techniques to meet special requirements. Essentially, the Section functions as a central service laboratory for the Corporation.

Significant changes in the regulatory environment during the past year affected the requirement for chemical analysis. Application of the "Transportation of Dangerous Goods Act", increased concerns associated with handling of hazardous materials, constraints on temporary storage and disposal of industrial materials, and the Municipal-Industrial Strategy for Abatement (MISA) all increased the need for chemical analysis. During the

year, the analysis of PCBs in transformer oils was fully automated. Robotics allowed the handling of increasing volumes of "rush" analyses. Dual-column capillary gas chromatography was developed to relieve the pressure of handling large numbers of gas chromatography and mass spectrometry analyses. A complete screening of effluents from all power plants was carried out under MISA protocols to develop the required materials handling and the analytical protocols for the regulation development phase, which is scheduled to occur in 1988.

Laboratory capabilities were enhanced in the areas of gas chromatography, liquid scintillation counting, and x-ray fluorescence. The labour-intensive analysis of gases in transformer oils, used to identify transformers likely to fail, has been fully automated. A new analyzer allows carbon in water to be analyzed at levels of interest to thermal power plant operators.

The carbon-14-containing solid from the annulus of Pickering NGS Units 1 and 2 was studied in detail. It has not yet been possible to define a particular molecular structure for the material, but the best evidence available shows it to be a carbon-nitrogen-oxygen polymer. Studies were carried out on the oxidation of the carbon-14 to determine if it could be gasified by heat and oxygen. These studies are ongoing.

Biological Research

In 1987, the Biological Research Section continued to contribute to the Corporate program to assess biota around generating stations. Components of the program included field surveys, vegetation studies for right-of-way management, radionuclide studies, and work in behavioural fish control systems.

The goal of the vegetation control program is to identify more effective and more environmentally responsible means of controlling undesirable vegetation on transmission and distribution rights-of-way. Past studies have



Experimental acoustic devices were installed at the Annapolis Tidal GS in Nova Scotia (top) and New York State (bottom). These devices are being evaluated as a state-of-the-art method to exclude fish from the water intakes of generating stations.

explored novel concepts of vegetation control, attempted to improve on existing control techniques, provided environmental information, and evaluated new products. The effects of tree cutting, population dynamics of the right-of-way vegetation, and the investigation of trunk injection of growth regulators were the main areas of investigation this year.

The radionuclide program focuses on determining the biological behaviour of tritium and other radionuclides produced by Ontario Hydro's nuclear facilities. This year, our investigations focused on deuterated materials, tritium and biofouling.

Site observations continue to enable

the environmental effects of the construction and the operation of generating stations to be determined. For example:

a) At Nanticoke TGS, an investigation of the biological consequences of the elimination of tempering of discharged cooling water was carried out. In addition, a summary of the influence of industrialization on the aquatic environment around Nanticoke was prepared.

b) At Bruce NGS, a year-one post-operational study focused on small-mouth bass reproduction and recruitment. Investigations of round whitefish spawning continued.

c) The effects of the Big Chute hydraulic development are being

assessed at Six Mile Lake, and modelling is being undertaken to determine whether changes in the direction and volume of inflow will affect the habitats of fisheries.

d) Water quality, fish spawning habitats, and fish species distributed below Red Rock GS, were monitored to determine the effect of bank stabilization on the aquatic environment.

Environmental Science

The Section continues to investigate a number of options for controlling acid-gas emissions. The calcination and sulphation reactions of Ontario limestones were studied under simulated furnace injection conditions.



This laser probe is part of the instrumentation package used to investigate the meteorological, microphysical, and chemical properties of freezing precipitation and fog in Southern Ontario. Results from this study are expected to lead to a better understanding of such weather and to identify areas for further study as part of a program to solve a 500-kV insulator icing problem.

Experimental facilities were built to study incremental sulphur dioxide capture in the ductwork of power plants that use dry sorbent injection with humidification. Similarly, filter deposits of power plants equipped with baghouses were investigated. A preliminary study of simultaneous sulphur dioxide and nitric-oxide control using transition metal catalysts was completed.

Three other projects initiated in previous years were completed. One of these was an international study of the environmental pathways for elemental tritium. The controlled release and monitoring of tritium at two field sites, one in Canada and the other in France were involved. Results demonstrated that the oxidation of elemental tritium to the more radiotoxic tritiated water vapour occurs only slowly.

Two other projects dealt with environmental pathways of acid gases. In one, the transport, transformation, and deposition of pollutants by clouds were studied by means of mathematical models. The models predicted that some clouds effectively transport pollutants vertically in the atmosphere. In addition, cloud processes were predicted to result in nonlinear relationships between air pollutant concentrations and acid deposition.

In the other project, the dry deposition of sulphur and nitrogen dioxides to a number of surfaces was measured. It was found that deposition rates to snow covered surfaces are very slow, and that nitrogen dioxide fluxes over vegetation need not be down to the surface, thereby indicating that the snow's surface can be both a source and an absorber of nitrogen dioxide. Results from these projects suggest that long-range transport models need improvement.

The licensing of nuclear stations and the design of safety equipment requires knowledge of the amount and the properties of radioactive aerosols that could be generated in the unlikely event of an accident. A capability to generate and to study aerosols was partially developed this year and was used to study the formation of liquid aerosols under simulated nuclear accident conditions.

The Section continues to support the Provincial and Corporate nuclear emergency preparedness program by providing expert advice in atmospheric dispersion and meteorological monitoring.

Expertise in the atmospheric sciences was applied to a problem of great current concern: the icing, wetting, and contamination of insulators. An instrumented field station was set up to measure the chemical and physical properties of storms involving freezing rain in Ontario. In addition, a laboratory study of insulator icing and wetting by the fog accretion mechanism was initiated in collaboration with a Canadian University.

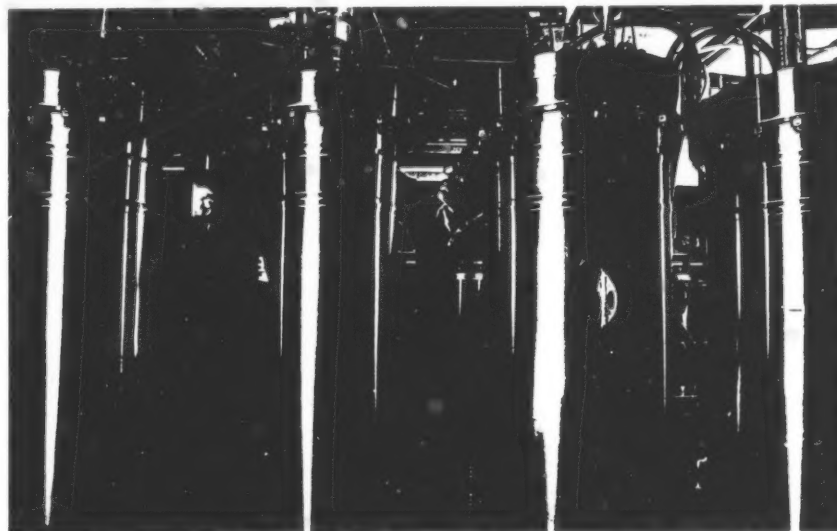
Materials Chemistry

Nuclear containment integrity activities involved a major inspection of the condition of non-metallic materials in the Bruce NGS 'A' vacuum building. Development of techniques to detect and quantify containment building leakage continues and a tracer gas method that uses ethylene was used

(GIS) and liquid dielectric transformers demonstrated that moisture migration, generation, and content reduced equipment performance. Moisture is present in solid insulation such as epoxy resin spacers, paper and press-board. The moisture is formed from material degradation under overload conditions. A computer program, MOISTGIS, has been developed to assess moisture content and distribution as it relates to GIS. The effect of moisture, temperature, oxygen, and gassing on by-product formation is being studied to establish power transformer acceptance criteria.

Several deuterated materials were synthesized and their performance fully characterized as part of a program to assess the potential for wider use of these materials.

Research to define immobilization and packaging requirements to allow



A gas chromatographic hydrogen isotope system has been sold to the Karlsruhe Tritium Laboratory in the Federal Republic of Germany. The technology has been transferred to Labserco Limited in Oakville, Ontario.

successfully during a four unit outage at Bruce NGS 'A'.

The occurrence of pressure relief duct seal failures during the commissioning of Pickering NGS 'B' initiated studies on the aging characteristics and performance of elastomeric seals. When examined, these seals, which had been in service for up to 17 years, revealed only slight changes in hardness and little oxidative degradation. Most deterioration appeared to be attributable to mechanical damage.

Research into the deficiencies of materials in gas-insulated switchgear

storage and eventual disposal of tritiated waste with acceptably low environmental releases was completed. A full-scale, prototype liquid waste immobilization system for use with water-extendible polyester resin as the solidification matrix was demonstrated to Design and Development and Nuclear Operations personnel.

Process Chemistry

The Process Chemistry Section seeks to provide effective and cost-efficient technology for treating liquid and gaseous streams in generating stations. For Hydro's nuclear stations, studies

are underway to develop highly selective sorbent materials for purifying water in the primary heat transport system, moderator and irradiated fuel bays. Static batch equilibrium tests and some preliminary column screening tests have already been performed.

The development in the laboratory of a gas chromatography system for hydrogen isotope separation allowed a commercially-scaled demonstration system to be designed, assembled, and tested. The work was funded by Karlsruhe Tritium Laboratory in West Germany, and the Canadian Fusion Fuel Technology project (CFFTP).

A patent based on the pilot-scale development of this system has already been granted in the United States. In addition, the commercially-scaled system, designed and assembled in cooperation with a Canadian company, is part of a technology transfer effort to involve a private company at

The study aims to quantify SO₂ capture, sorbent utilization, waste characteristics, and electrostatic precipitator performance. Work to enhance SO₂ capture and restore electrostatic precipitator performance through humidification has been completed. Overall SO₂ capture by this two-step process is approximately 63 percent.

To facilitate safe handling and disposal of the solid waste that results from limestone and lime injection into furnaces, detailed chemical and physical characterizations of solid waste have been made. The fixated wastes were found to resemble fly ash and certain earth materials, and being "non-leachate toxic", suitable for use as landfill or backfill.

The development of an electrochemical pilot plant and test facility for the synthesis of ethylene glycol came closer to completion. The design of a

nuclear plants. To date, CANDU reactors lead the world in steam generator integrity. However, a long-term research program is in progress to anticipate problems that may occur and to develop remedial measures to avoid or minimize their consequences.

The greatest risk to Ontario Hydro's steam generators is the formation of chemically aggressive conditions under sludge, which accumulates both on the secondary face of the tubesheet and in the crevices at the support plates. The rate at which these contaminants concentrate has been studied in laboratory autoclaves and a model has been produced to describe the process. Further study is aimed at determining the nature and severity of corrosion under sludge deposits. Last year, emphasis was mainly on Incoloy 800 tube material, which will be used at Darlington NGS.

The removal of accumulated deposits in steam generators may be required if under-deposit corrosion threatens the integrity of materials or if fouling of heat transfer surfaces results in power output reductions. A multi-year program to develop solvents capable of chemically removing these deposits was completed.

The most effective means of avoiding under-deposit corrosion is to minimize its formation. Deposits are formed mainly from the low levels of impurities produced by corrosion of the secondary system pipework. Deposits gain entry to the steam generator via the feedwater. Thus, as part of a long-term project to identify and, ultimately, to control the sources of these impurities, sampling equipment has been installed in a Bruce NGS 'B' unit.

The group was also active in decontamination studies in 1987. A major requirement of the CAN-DECON chemical decontamination process continues to be the development of a sulphur-free inhibitor. Detailed laboratory evaluations of three candidate inhibitors were continued this year through a collaborative effort by researchers at the Division, at the AECL-Chalk River Nuclear Facility, and at the University of Guelph. The scope of the Guelph study is being expanded by means of a grant from the Natural Sciences and Engineering Research Council. Investigations of the fundamental mechanisms of corrosion inhibition at carbon steel surfaces under decontamination chemistry conditions are being carried out.



In the Process Chemistry Laboratory, a leachate extraction test is being performed as one of the many tests conducted to characterize wastes produced by the various acid-gas control processes under investigation.

a developmental stage of the project. Following successful testing in the demonstration system, an engineering design of equipment for hydrogen isotope separation at the Karlsruhe Tritium laboratory was provided.

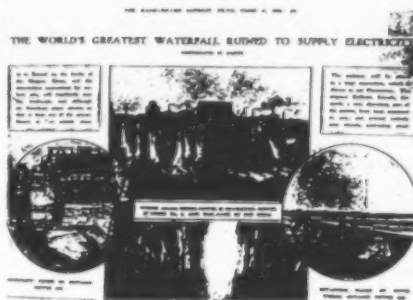
Sulphur capture by in-furnace injection of calcium-based sorbents has been studied under conditions simulating full-scale operation at Ontario Hydro's 640-MJ-per-hour Combustion Research Facility. These studies are a significant component of the Corporation's acid-gas control program.

12-kg-per-hour electrochemical pilot plant has been completed. The design was complicated not by the chemistry, but rather by the need to contain and safely dispose of chemicals and electrolytes in the product stream.

Corrosion Chemistry Decontamination Project

Degradation of steam generator tubes, which may result in primary coolant leaks, is a major concern in

CIVIL



Views on power development at Niagara Falls as featured in the London Illustrated News in 1906.

Manager's Report

The Research Division's 75th Anniversary year has been a challenging one for the Civil Research Department. The continuing construction of the Darlington nuclear generating facility, rated as one of the world's mega projects, gave the Department numerous opportunities

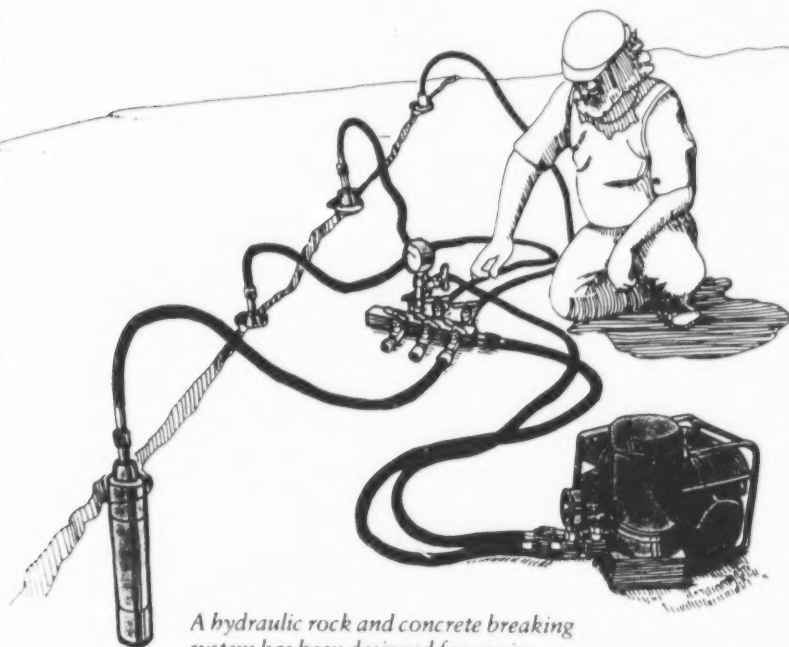
to utilize its expertise in such specialty areas as advanced concrete technology and geotechnical engineering.

Nuclear Generation Division called upon the Department to assist in testing and monitoring their nuclear containment structures, and currently, reactor and vacuum buildings are being tested at the Pickering and the

Bruce facilities to ensure their continued safety and reliability.

Ontario Hydro's large commitment to nuclear energy makes studies related to the safe and environmentally acceptable storage, transportation, and ultimate disposal of irradiated nuclear fuel a high priority. Thus, concentrated effort has been made by the Department to cooperate with the Design and Development Division of Ontario Hydro and with Atomic Energy of Canada Limited, both of which are involved in these types of studies.

In addition to our commitment to ensuring the safe and reliable operation of Ontario Hydro's important nuclear structures, a concomitant concern is reflected in Civil Research's effort to ensure the optimal performance of Ontario Hydro's hydraulic generating facilities. This year, the Department has played a significant role in the Dam Safety Program. The work involved site investigations, through the preparation of design



A hydraulic rock and concrete breaking system has been designed for use in areas where blasting techniques cannot be safely used, such as near structures, sensitive equipment, and in residential areas. The rapid, portable system can be pressurized from a safe distance with the aid of a hydraulic pump and high pressure hoses.

CIVIL

Manager

Dr. T.W. Klym

Concrete Technology

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Concrete Control

Mr. H. Caratin

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Soil Sciences

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reviews, to rehabilitation and performance monitoring. These efforts have led to the Department's participation in remedial work on a number of facilities. Work was carried out at Crystal Falls GS, Bray Lake GS, and at DeCew Falls GS. In addition, rehabilitation work was done on the Cedars Channels and Waba Dams.

Another Corporate priority is minimizing the impact on the environment of a number of power generation operations. The Department has thus given increased attention to wastes generated from thermal plants; work was done in the areas of acid flue gas control, fly ash management, and in the disposal of flue gas desulphurization wastes. Similarly, considerable effort has been devoted to developing controls on wastes generated from nuclear power facilities. Two such controls



As part of the corporate Dam Safety Program, researchers installed pendulums and precise surveying stations to measure the deformation of the Pine Portage concrete dam.

currently under study involve radioactive carbon emissions and the disposal of reactor and irradiated nuclear fuel wastes, the latter being of great environmental concern.

Soil Sciences

In the area of thermal plant waste management, the Soil Sciences Section continues its involvement in specialized geotechnical and hydrogeological research and consulting. To provide input into the management of coal ash produced by coal-fired stations,

laboratory and field projects were conducted to investigate the movement of contaminants beneath the coal ash lagoon at Nanticoke TGS and to provide design values for the analysis of the stability of the long-term ash storage mound. In addition, innovative utilization options for the ash produced at the Lakeview and Nanticoke TGS facilities were investigated.

Numerical modelling and full-scale transmission tower foundation testing led to design innovations in the new narrow-based 500-kV transmission towers. Participation in transmission tower refurbishment studies included the evaluation of the condition and load carrying capacity of foundations of transmission lines constructed more than 30 years ago. These studies are expected to provide a greater insight into the life expectancy and reliability of old lines.

With regard to technology transfer, a training seminar was conducted by section staff for Chinese engineers in Beijing; the subject of the seminar was the "Theoretical Analysis and Practical Applications of Transmission Tower Foundations". The seminar was presented to engineers from the Electric Power Construction Research Institute and was funded by the Canadian International Development Agency.

Soil Sciences continued to support research and development efforts in medium- and high-level radioactive waste disposal studies. Through Ontario Hydro's Technical Assistance Program, which supports the AECL/WNRE Waste Management Program, studies are ongoing in the near-field heat and moisture modelling experiment for the reference design of underground disposal of irradiated fuel wastes. Ontario Hydro's technical expertise in thermal modelling, grouting, and backfilling was sought by AECL/WNRE for their Underground Research Laboratory experiments which are being carried out near Pinawa, Manitoba.

The Section plays a significant role in soil thermal measurements and in the theoretical modelling of heat and moisture as related to underground power cables, ground source heat pump performance and underground nuclear waste disposal. This expertise has been marketed to outside utilities through Ontario Hydro's New Business Ventures Division.

As part of a 7-year performance review of the Corporation's concrete and earth water-retaining structures,

the Dam Safety Program was provided with consultation services and reviews of historical data. In addition, state-of-the-art technology was applied to investigations of the DeCew Falls GS dykes and the Arnprior GS Waba Dam to provide parameters for inclusion in dam stability reviews. Instrumentation was installed at Pine Portage GS and other dam structures in support of the Thermal and Hydraulic Generation Division's long-term performance monitoring programs.

Rock Sciences

Rock Sciences is participating in a multi-agency effort (the Integrated Stress/Neotectonics Study for Seismic Hazard Assessment) to improve current capability to assess site-specific seismic hazards with low levels of probability of occurrence. The aim



A dynamic triaxial test is being performed on soil taken from one of Ontario Hydro's dams to determine the resistance of the soil to earthquake-type loading.

of the project, which involves such agencies as the Geological Survey of Canada, the Atomic Energy Control Board, the Ontario Geological Survey, the Ontario Centre for Remote Sensing, Laval University, the New Brunswick Department of Natural Resources, and the University of New Brunswick, is to allow application of more stringent criteria to critical structures than those now required by the National Building Code of Canada.

In 1987, research was directed at determination of the three-dimensional stress field in a rock mass and the integration of the observed neotectonic data with this field on an outcrop scale. Several field sites were involved. In southern Ontario, the integrated geo-scientific approach was tested at a research site (the Robindale quarry) near Napanee, where ground probing radar revealed evidence of geologically recent movements. Memorial University in Newfoundland and Queen's

University in Ontario are carrying out a hydraulic pumping study to test the effect of hydrogeological changes on seismic activity.

Concrete Technology

The past year was a challenging one for the Concrete Technology Section. Projects were designed to address both the Corporation's current and anticipated needs.

In order to facilitate access through swamps, muskeg, and lakes, most transmission line construction must be performed during the winter months. Thus, since cement-based concretes and grouts require costly protection from the environment during the early stages of curing, a need arose to develop materials that were not adversely affected by subfreezing temperatures. A polymer concrete suitable for use at temperatures down to minus 25°C without the need for protection was developed, and substantial savings in the cost of tower-footing construction were realized. In northern Ontario, the development of this novel material has facilitated cost-efficient construction

of a major guyed extra-high-voltage transmission line under severe winter weather conditions.

An on-going concern in structure maintenance is the selection and use of repair materials. A rehabilitation and repair program was undertaken to assess the use of both organic and inorganic materials in hydraulic, thermal, and nuclear structures. Considerable work has been done to identify the physical characteristics of candidate materials, and their long-term performance is currently being evaluated.

In 1987, a four-year study on the behaviour of reinforced concrete structures subjected to thermal gradients was completed. The program involved the construction of models and their monitoring during tests. The result was the formulation of analytical methods to predict behaviour. A computer program to analyze structures subjected to thermal and mechanical loads was developed, thus enabling designers to predict more accurately the consequences of thermal stresses.

Concrete casks are being considered for storage of irradiated fuel. However, the development of these casks

requires costly testing of prototypes. It is therefore necessary to test scaled-down versions. A major difficulty with scaling-down is the determination of the scaling effect on observed results. Thus, a program was undertaken to investigate size-effect on specimens subjected to a drop test. Four models of varying size were instrumented and tested to determine their response to impact loads. The data from this study will help in predicting the behaviour of a full-scale prototype.

Concrete Control

The Concrete Control Section has inspected and tested approximately 70,000 m³ of concrete placed at the Darlington NGS construction site. A crew of 12 inspectors sampled cement, aggregates, and concrete to check for conformance with rigid project specifications.

In addition, inspection was provided during the rehabilitation of the Cedars North Channel Dam, Eugenia GS, and the Ontario Power Generating Station's intake structure and screenhouse.



Laboratory concrete specimens, stored in controlled temperature and humidity environments, are regularly monitored as part of a practice to ensure the quality of materials used in Ontario Hydro's structures. In addition, an evaluation of the effectiveness of corrective measures is made in cases where the use of problem materials cannot be avoided.

DIVISIONAL PROJECTS



A scene from the parade that preceded the formal inauguration of electric power service in Berlin (now Kitchener) in 1910.

Manager's Report

The Divisional Projects Department interfaces with various groups within the Division, within Hydro as a whole, and with other groups external to the Corporation. Its activities may be subdivided into Special Studies, Research Management Studies, and Research Business Support.

In the category of Special Studies, the Department carries out liaison and coordinating functions, both within and external to Ontario Hydro to identify new areas of research and, where appropriate, to initiate projects. Advice and resources are drawn from the Research Division and other Hydro Divisions, from industry, universities, and government agencies.

In 1987, emphasis was on increased Research Division participation in the development of new electrotechnologies of benefit to Ontario industry. Work continued on the coordination of plasma arc and advanced ceramic programs. Cooperation with the Metallurgical Research Department and the Marketing Branch resulted in a plan for the establishment of an

electric furnace facility for use in cooperative research and development on ferrous and non-ferrous metals.

Work began on an industrial laser program. Links to the laser community were strengthened by the appointment of a member of the Division to the position of adjunct professor in the Laser Applications Laboratory at York University and to the User Facility Committee in the Centre of Excellence in Laser and Lightwave Research at the University of Toronto. Industrial partners for a collaborative program of research and development of ceramic powder production technology have been identified and proposals for funding are being developed.

Production of technological forecasts is ongoing. This year a Delphi study, focused on advanced industrial materials, was carried out in conjunction with the Operations Research Department. Addressed were the areas of ceramics, plastics, metals, and electrolytic and superconducting materials. The study was directed at Marketing and Research personnel. A paper on technology forecasting was co-authored with Operations Research personnel, and this will be presented at the International Conference on Technology Management in February, 1988.

Artificial Intelligence (AI) is an important area of inquiry. Regular issues of the AI newsletter continue to be a valuable tool for communication within Hydro's AI community. A computer program was developed which incorporates some of the expertise of a senior meteorologist and will assist in forecasting conditions likely to produce icing on transmission lines. A small neural network simulation was designed to investigate the speed with which the network can be taught to distinguish between simple shapes.

The Department provides external contracts support. A guide for the production of research contract proposals, a general confidentiality agreement, and intellectual property clauses for external consultants were some items developed during 1987.

This year was the Research Division's 75th Anniversary and the Department took the lead role in planning and organizing celebrations. An anniversary logo was commissioned and has found a number of applications. A video that traces the history and the accomplishments of the Division was produced, and this was first screened during the Anniversary Open House in June. Over 1,500 people visited the Division during this 3-day event. In October, a symposium on the "Value of Research to Society" was hosted by the Division at a local hotel. Guest speakers from other organizations with an interest in research presented papers describing the significant role research plays in supporting modern society.

The Division has many visitors. This year, the Department organized over thirty tours. Among the visitors were delegations from the Lawrence Berkeley Laboratory and from various foreign utilities and research organizations. University students from local and foreign institutions and members of Hydro's own training program also participated in many tours.

Posters promoting the achievements of the Division were produced to encourage students to consider careers in science or engineering. In addition, the Department participated in the celebration of the 100th Anniversary of the Association of Professional Engineers of Ontario. A display was produced and sent to various locations in the province.

DIVISIONAL PROJECTS

Manager

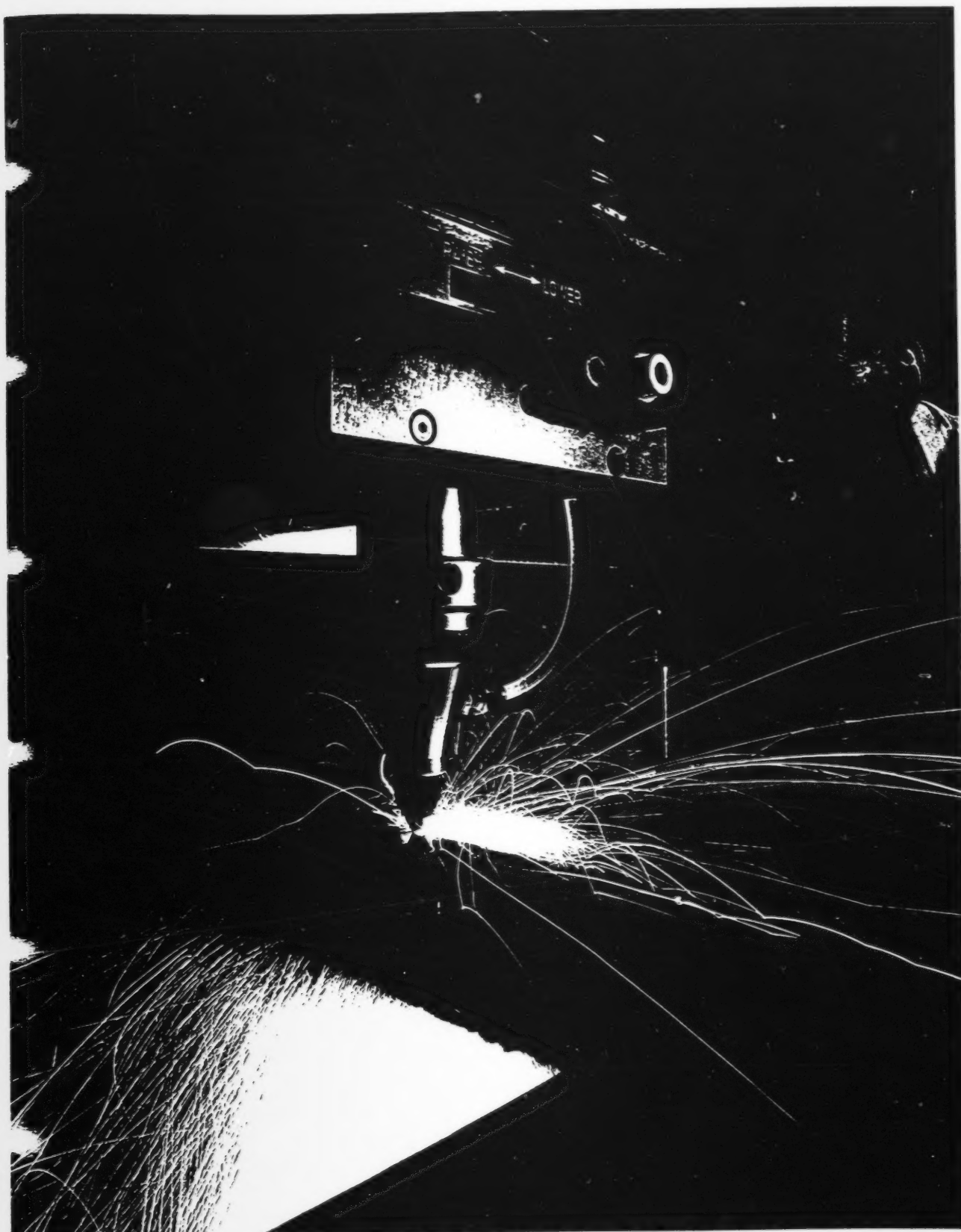
Mr. J.G. Cassan

Principal Research Engineer

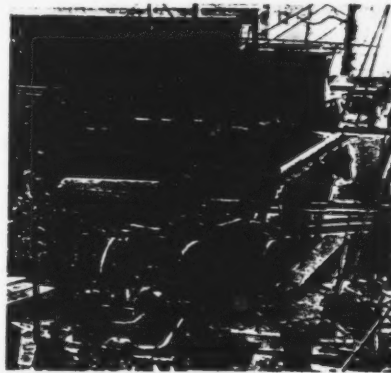
Dr. C.J. Simpson

Research Business Relations

Dr. G.R. Floyd



To further assist Ontario industries, researchers are studying the cutting, welding, and drilling of various materials with an industrial carbon-dioxide laser.



Construction of Hydro's first Head Office Building at 610 University Avenue in May of 1915.

Manager's Report

The Electrical Research Department's research and development program is extensively interactive with other Divisions in Ontario Hydro and, where appropriate, with industry and the public. The objective of the overall program is to serve the present and future needs of both the Corporation and Ontario's Municipal Utilities and to work together with Canadian Industry in an effort to introduce energy saving electrotechnologies in manufacturing.

Research studies of benefit to Ontario Hydro and its customers are also carried out under contract to organizations such as the Canadian

Electrical Association and the Electric Power Research Institute in the United States. It is of interest to note that the general trend in utility research towards near-term development projects and generic problem solving was also evident in the overall Electrical Research R&D program in 1987. While several long-term studies continued, primarily in advanced diagnostics, artificial intelligence, and high-power laser applications, a number of high-priority near-term objectives were pursued in close cooperation with other Divisions. Two programs which are unique to Ontario Hydro, deserve special mention. The first concerns the reliable performance of 500-kV power transmission facilities during atmospheric conditions such as freezing rain, dense fog and near-freezing temperatures. The second aims at increasing generation limits for major power plants operating under severe transmission constraints. Both of these in-house research programs have attracted international attention and could well lead to new utility practices.

To alleviate the consequences of increasing limitations on the construction and operation of power lines, an in-depth design optimization program is underway that takes into account considerations of terrain, environment, material properties, and alternative design techniques. The program also addresses optimum utilization of existing transmission lines. Initial results of the above studies were part of the content of a ten-day seminar presented in China under the auspices of the Canadian International Development Agency.

A new CSA Standard (C-233.1), Gapless Metal-Oxide Surge Arresters for Alternating Current Systems, which has been in preparation for five years, has reached the stage of publication. This document is the

most complete standard on the new metal-oxide surge arresters and will meet the needs of Canadian power utilities for years to come.

A defacto standard in hydraulic generator maintenance was established in 1987 with the completion of an agreement with a Canadian company to manufacture and market world-wide, a new diagnostic instrument for on-line insulation quality monitoring. This instrument is one of a group of electronic devices both developed and still under development for use in the power system. Many of these devices will ultimately be integrated in a "Power System Integrity Control" system, now in the early stage of development.

Several initiatives were taken in support of distribution system maintenance and customer equipment performance. Consultations with the Municipal Electrical Association resulted in a decision to direct these activities more formally in the best interest of Ontario's Municipal Utilities.

A summary of the research and development effort in the Electrical Research Department follows.

Transmission & Special Projects

A major concern this year was the occurrence of multiple flashovers of 500-kV line suspension and station post insulators during atmospheric conditions marked by light freezing rain, followed by fog and rising temperatures. Because of limited transmission facilities from nuclear generating stations, the determination of cause and the need to find a remedy for the flashover problem became critical. Thus, in cooperation with Region staff, and Production, Power System Program and Design and Construction Branches, an extensive laboratory and field testing program has been put in

ELECTRICAL

Manager

Mr. A.F. Baljet

Principal Research Engineer

Mr. O. Nigol

Electrical Testing & Development

Mr. J.N. Edgar

Electronics & Instrumentation

Mr. R.D. Brown

Science

Dr. N. Anyas-Weiss

Stations & Underground

Dr. G.L. Ford

System Studies

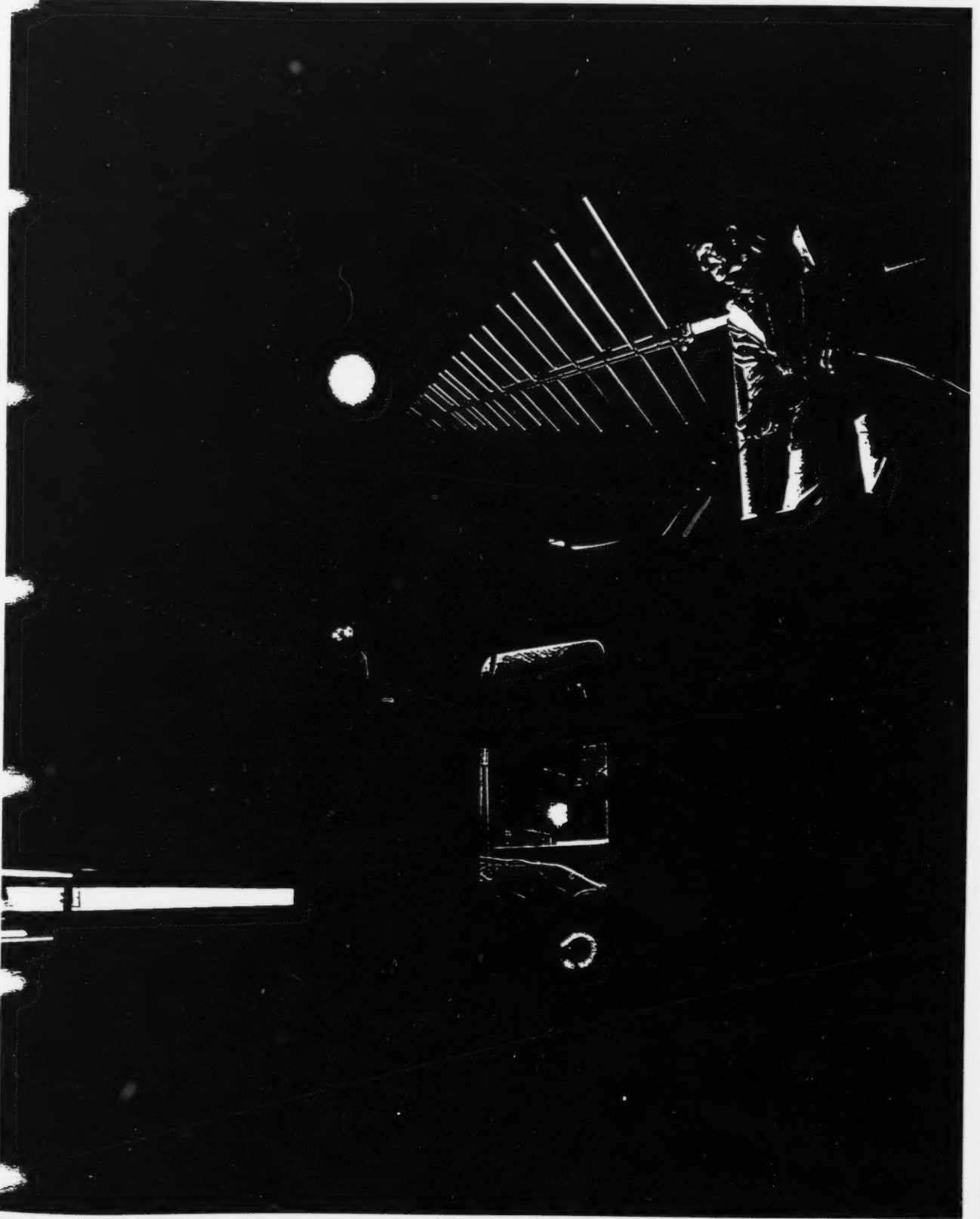
Mr. D.C. Lee

Transmission & Special Projects

Mr. C.C. Erven

Utilization

Mr. J.M. Bell



Electromagnetic interference measurements were taken for the Toronto Transit Commission to verify that their H6 subway car complies with commission specifications. Normal subway operation was suspended while these tests were performed in the early morning hours at an open section of track near the Kipling subway station.

place to assess the performance of available insulator arrangements and to evaluate new designs based on an understanding of the flashover mechanism.

Load loss due to the high failure rates of some low-voltage station bus support insulators led to field tests that resulted in the development of a positive puncture detector for field use. Another new development was a prototype grounding stick to protect cargo handlers from exposure to hazardous electric shocks caused by electrostatic charging of hovering helicopters. This device was successfully developed and tested during repairs to the top of a Nanticoke TGS stack.

Contributions continue to be made at both a national and an international scale to the development of better performance standards and application guidelines for the use of gapless metal-oxide surge arresters. A long-term study of the thermal properties of metal oxide ceramics, widely used in these surge protective devices, revealed the range of stability characteristics of thirteen commercially available materials.

Algorithms were developed for computing the detection efficiency and the location quality of results from the Ontario Cooperative Lightning detection network. These models demonstrated that an additional lightning receiver would reduce the false alarm rate for arming the Load-Generation Rejection Scheme of the Bruce NGS.

A new low-loss ACSR conductor has been developed and tested, and it gives a reduction in AC resistance of 3.8 percent. Use of low-loss conductors could significantly reduce transmission losses without adding to the cost of the transmission lines.

Studies of the thermal behavior of conductors validated Ontario Hydro's state-of-the-art real-time weather monitoring system. Improvements in the use of weather data will lead to improved and safer use of existing transmission facilities.

System Studies

The stability and security of the interconnected power grid remains a concern, with the continuation of locked-in generation at the Bruce Complex and a proliferation of operating interface limitations. To help stabilize low-frequency inter-area modes of oscillation, power system stabilizers have been installed on some of the

Pickering NGS units, with stabilizers for the remainder scheduled to be installed early in 1988. A new power system stabilizer for hydraulic units was developed. Testing at the Sir Adam Beck II GS confirmed the validity of plant models essential for optimizing performance of our automatic generation control system.

In conjunction with the Electronics and Instrumentation Section, a prototype Power System Disturbance Recorder was developed. When installed at several stations, it will allow the acquisition of disturbance data and facilitate the re-creation of system events and the calibration of system simulation programs.

A new relay to protect the stator windings of turbogenerators was developed and applied at Lakeview TGS. It will become the standard for all future installations. Inadequacies in the coverage of some existing impedance-based line relays were identified and remedial action was recommended. Evaluation of protection systems for new applications continued, with the focus turning to relays for protection of series-compensated lines. Equipment has been purchased and new testing techniques have been developed to facilitate the evaluation of several relays for series-compensated line protection.

Fibre-optic technology vies increasingly with microwave technology as a communications medium. Testing was conducted on three different composite fibre-optic skywires to develop standards and to determine their suitability for future application. Radio and television interference continues to be an important area of work, and a major study of interference from distribution lines was completed this year as part of a Canadian Electrical Association (CEA) contract. The quality of the waveform supplied to customers is of increasing concern. To facilitate waveform analysis in the field, a Power Harmonic Analyzer (PHA) has been developed under a CEA contract.

Electrical transients due to lightning, switching or faults must be controlled to ensure system-wide security. Tests and computer simulations led to practical formulas describing the surges which stress generators and large motors. New models of the magnetic behaviour of transformers were developed. Simulations showed that arresters bonding high-voltage cable pipes to station ground required upgrading. Grounding system tests at

Merivale TS have led to improved grounding design procedures.

Stations and Underground

A major project sponsored by the Electric Power Research Institute (EPRI) is underway to improve the reliability of epoxy spacers in gas-insulated equipment. Six subcontractors, located in Europe and in North America are working with Ontario Hydro on a range of failure mechanisms, which include partial discharge in voids, electrical treeing at epoxy and metal interfaces, tracking of surfaces, and long-term chemical and thermal aging. Considerable progress has been made in the factory production of spacers with controlled defects and in the development of advanced diagnostic instrumentation.

To defer the costs of new plant, more precise determination of underground cable ampacities and studies of alternative criteria for loading of one or more underground cable circuits during an outage of a companion circuit are being undertaken. Several field measurements were performed on the 115-kV Riverside Junction to Strachan TS circuits. In addition, advanced computational techniques have been developed for analysis of temperatures in the vicinity of underground cables.

An external agreement was finalized to manufacture and market the Partial Discharge Analyzer for Hydro Generators (PDA-H). A complete coupler installation and servicing package was included. Development of this on-line diagnostic instrument, now in world-wide use, was sponsored by the Canadian Electrical Association. It is credited with annual savings amounting to millions of dollars within Ontario Hydro alone. The final report on the PDA-T, a similar instrument for use with turbine alternators, has been completed, thereby completing a four-year project. Further work is required prior to commercialization.

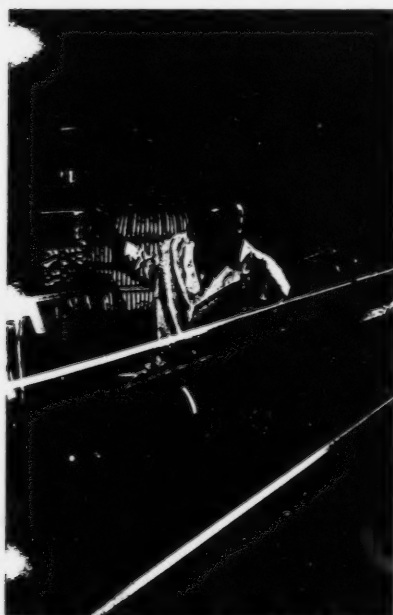
A five-year EPRI project on the turn insulation capability of large AC motors has been completed and a draft of the final report submitted. This study of one of the major causes of motor failures explored the surge environment in power stations and factors associated with motor insulation strength. Recommendations were made with respect to quality control in motor coil manufacture, cable feeder arrangements, and switching practices. Based on this work, Ontario

Hydro is examining its motor specifications.

A great deal of progress was made on another ongoing EPRI-sponsored project, designed to improve methods for predicting the life of motor and generator insulation systems. Several new types of instruments were developed that permit better on-line thermal, mechanical, and electrical monitoring of rotating machines. In addition, a handbook was prepared to advise utility maintenance engineers on how to evaluate the condition of rotating machine insulation.

A third EPRI project to develop an expert system to monitor generator condition and performance is progressing on schedule. A host utility has been selected to test a prototype system.

This year, activities in the transfer of induction heating technology to Ontario's industries increased. Seminars, consultation services, and feasibility studies on the application of various electromagnetic processes were provided to several outside companies and organizations. These processes include induction heating, annealing, induction brazing, and induction hardening. As well, high-rate-of-energy release techniques are being adapted for controlled breaking of concrete and rock. Research in controlling shock waves as a function of electromagnetic and mechanical parameters is being conducted.



Shown is performance testing of an AC device for spacer repositioning in the CANDU reactor.

Electrical Testing & Development

Analytical and laboratory tests led to significant advances in distribution system technology for the enhancement of the economics, security, and safety of Ontario's distribution plant.

Application of these advances to current problems produced effective technical support for operating personnel. Included were a comprehensive arrester application guide for all aspects of surge protection, including new metal-oxide arrester applications, cold-load pickup practices designed to preclude excessive outage time, user-assisted computer programs to facilitate transformer life estimates and transient recovery voltage studies, and a series of recommendations for minimizing underground cable costs through improved purchase specifications and installation practices. In addition, improved equipment designs continue to evolve from the development of performance requirements and from close liaison with the electrical industry. Negotiations are ongoing with manufacturers to produce and market a fault current diverter protection device and a device to prevent arrester explosions.

Transmission and distribution field and laboratory testing services were enhanced to increase diagnostic capabilities and further improve operational efficiency. In addition, the implementation of digital technology in instrumentation and data analysis systems moved forward. Special

efforts were made to accommodate studies of flashover performance of 500-kV insulation during critical icing and fog conditions. The environmental facilities developed for this program are unique to the industry.

Electronics & Instrumentation

Recent advances in semiconductor technology have had a major impact on the design of electronic equipment for power systems by providing access to the high level of reliability required for applications on increasingly complex electric power systems.

For example, the Programmable Auxiliary Logic Controller (PALC), which was designed some years ago to replace conventional electromechanical relays in station protective relaying systems, has been upgraded to take advantage of the recently developed Application Specific Integrated Circuit (ASIC) technology. An ASIC has been incorporated into PALC which, in addition to implementing the functions of the original digital input circuitry, provides additional redundancy and self-diagnostics, thus providing a reliability level not achievable with conventional integrated circuits. To expand the potential applications of PALC further, an Analog Input Module is being developed to measure the magnitude, frequency and phase of voltage and current signals.

A hand-held recording ammeter called the ERA-3 has been developed to help Regional marketing personnel



Tony Griffin (Research), Carl Kropp (Ottawa Hydro) and Richard Morris (Energy Management Branch) discuss the application of the ERA-3 to collect load data for helping customers optimize their energy usage.

collect load-profile data of a commercial or an industrial customer's power consumption. The data is stored in a solid-state memory that can be read by a computer and analyzed. Using this information, Hydro consultants can help customers make efficient use of their electrical energy.

A portable computerized version of the Soniscope, an instrument used to determine the integrity of hydroelectric dams and other mass concrete structures, has now been completed. By using digital signal processing techniques, the operating range and many other characteristics of the instrument have been significantly improved over the original Soniscope which was developed almost 40 years ago.

A program has been initiated to upgrade the facilities of the Electrical Standards Laboratory which maintains the Corporation's standards for electrical units such as the volt, ampere, ohm, watt and watt-hour. These standards which are all directly traceable to national standards, are used in conjunction with precision equipment to calibrate other working instruments, including those which ultimately ensure the accuracy of our customer billing meters. The upgrade is aimed at providing a state-of-the-art facility to not only improve the integrity of our calibrations, but also the efficiency with which they are made.

Science

The mission of the Science Section is to carry out longer-range research using advanced technology to produce new inspection techniques and to develop new industrial applications for advanced electrical technologies. For example, the holographic technique developed in previous years as a method for assessing the integrity of small objects has been improved for field application and can now be used without elaborate vibration-isolation equipment. This represents a significant breakthrough.

An Industrial Laser Laboratory with a 1.5-kW CO₂ laser was established to explore the industrial applications of high power lasers, such as in the cutting, welding, and surface treatment of metals and ceramics. In addition to meeting Ontario Hydro's internal research needs, the laboratory aims for technology transfer to Ontario industry. Laser-based techniques, such as laser-based phosphor thermometry which allows remote temperature



Engineers conduct the field testing of the newly redesigned Soniscope.

measurement, were developed. An application of this is a prototype rotor temperature sensor which was built for EPRI to monitor the temperature of rotors in turbo-generators for diagnostic purposes.

Research activities in support of the Corporate-wide Biological Effects of Electromagnetic Fields program have been substantially expanded. Advanced instrumentation and test techniques to measure the environmental impact of electrical and magnetic fields from power lines and to evaluate risk hypothesis in the laboratory were developed. This work forms

part of the recently created research collaboration in this area between Ontario Hydro, Hydro Québec and Electricité de France.

The discovery of High Temperature Super-conductors (HTSC) in 1987 may have significant impact on Ontario Hydro's future power system. A HTSC Task Force was formed to monitor this new development and study potential applications. Research in material fabrication and characterization was carried out in a number of sections.

The Section has developed a computer-vision based seam tracker for automatic welding which will be incorporated into a system being built by the Metallurgical Research Department. In addition, the Section has developed expert systems in the areas of protective coatings and the interpretation of eddy current signals, which are used to diagnose faults in pipes. Expert systems improve effectiveness by enabling others to deal with routine questions without the direct assistance of experts. A Robotics and Artificial Intelligence Laboratory (RAIL) with an Apollo work station is being prepared for research into autonomous robots for use in hazardous environments. The benefit to cost ratio from having an autonomous robot carry out repair or decommissioning work in a nuclear environment is enormous. The Research Division has joined the Pre Competitive Applied Research Network (PRECARN), which is a



Tritium separation requires high-power pulses from a CO₂ laser system, shown here being adjusted with the aid of a helium-neon laser.

non-profit company that sponsors research into artificial intelligence and robotics.

Separation of tritium and carbon-14 from effluents in fission and fusion reactors by lasers and by cryogenic distillation was examined, and preliminary results show that the two processes are competitive with conventional separation processes. Measurement of the fundamental parameters required for building a pilot plant is underway. The purpose



A Robotic and Artificial Intelligence Laboratory has been set up to develop, amongst other things, a robotic system for use in hazardous environments.

of this work is to develop new and effective disposal options for Hydro, and to help the fusion community speed the development of an effective fusion power source. Selective depletion of zirconium-91 has been demonstrated in experiments using Atomic Vapour Laser Isotope Separation (AVLIS). The experiments were performed in collaboration with the National Research Council of Canada. AVLIS for zirconium separation is of interest because the zirconium depleted in zirconium-91 has a lower neutron absorption cross-section, which allows greater flexibility in nuclear reactor design. In addition to isotope separation, the nuclear science group developed a device able to verify fuel bundles in the spent fuel bays so that Hydro can meet its obligations to the International Atomic Energy Agency (IAEA).

Utilization

To help Ontario Hydro customers gain increased benefit from electrical power, the Utilization Section tests and develops more efficient and effective uses of electrical energy.

Sixty-five Ontario industries worked with the Section during the past year to evaluate the usefulness of various electrotechnologies for their

processes. Some remarkable advantages were identified through cooperative testing in the Process Applications Laboratory, and as a result, several Ontario companies are implementing new electrotechnologies to increase their efficiency and improve their competitive position. In addition to this type of assistance, basic development continues on industrial heat pumps and dehumidifiers, advanced ceramic processes, and low-temperature plasma.



Ontario industries benefited from cooperative studies with the Utilization Section. (Top) This year, product testing led to the installation of a microwave dryer at a Toronto ceramics company. The dryer reduces process time from twenty-four hours to about eight minutes. (Bottom) Work with an Ontario manufacturer was conducted to improve the performance of an innovative heat pump. The upgraded appliance has attracted world-wide attention.

In the residential sector, the emphasis was on space and water heating. Of prime importance was the heat pump, and work to further develop and popularize this type of system was carried out. Ontario Hydro has developed a heat pump which is highly efficient at very low outdoor temperatures. In addition, researchers have worked with industry to achieve a variety of new heat pump designs with very low winter peak power demands. The performance of several systems is being measured in installations throughout Ontario, some in cooperation with the Swedish State Power Board.

Strategic conservation measures, such as those provided by the Division's heat pump research, benefit

Ontario Hydro and the Municipal Utilities and offer energy consumers greater value than other options. Other work designed to help customers save energy focused on improving window technology, retrofitting insulation and improving building ventilation.

Tests in residential and commercial ventilation heat recovery for domestic hot water production have been conducted. Results show potential for widespread use, especially in commercial areas. One restaurant demonstration won the prestigious American Society of Heating, Refrigerating and Air Conditioning Engineers award for outstanding achievement in energy efficiency.

MECHANICAL

Manager's Report

The Mechanical Department is a research and development resource which provides technical expertise and experimental and testing facilities related to the mechanical disciplines.

The Department is organized into four Sections, each with a specific functional responsibility to deliver



The Queenston - Chippawa plant (Sir Adam Beck GS #1) at dinner time in 1919.

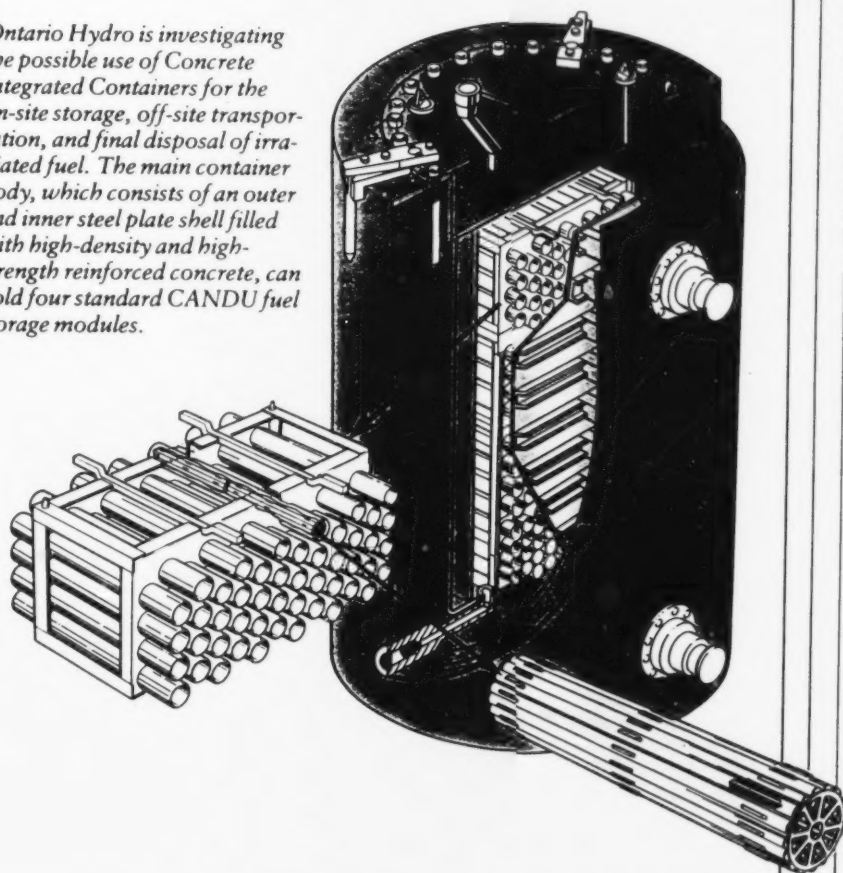
products contributing to the improvement of performance, reliability and safety of components and mechanical processes utilized in Ontario Hydro's overall operation.

Resources include 94 professionals and technical support staff. The annual operating budget is 8.8 million dollars. In 1987, activities spanned areas ranging from the development of

mechanical performance requirements for fibre-optic cables to full-scale testing of an 11,000 horsepower, primary heat-transport pump for Darlington NGS. In addition, a Senior Research Engineer leads and directs long-term corporate research needs on the structural aspects of the transmission and distribution systems.

The Senior Research Engineer's most important initiative in 1987 dealt with aging transmission lines. As the age of transmission lines increases, with the oldest now past the 80-year mark, an investigative program to help prioritize lines for refurbishment has been initiated. Preliminary investigations indicate that outage rates increase with line age, making necessary a major effort to upgrade lines that have been in service for 50 years or more. Subsequent to these findings, on site investigations of sections of older lines in the process of being replaced

Ontario Hydro is investigating the possible use of Concrete Integrated Containers for the on-site storage, off-site transportation, and final disposal of irradiated fuel. The main container body, which consists of an outer and inner steel plate shell filled with high-density and high-strength reinforced concrete, can hold four standard CANDU fuel storage modules.



MECHANICAL

Manager

Mr. G.J. Clarke

Senior Research Engineer

Dr. D.G. Havard

Applied Mechanics

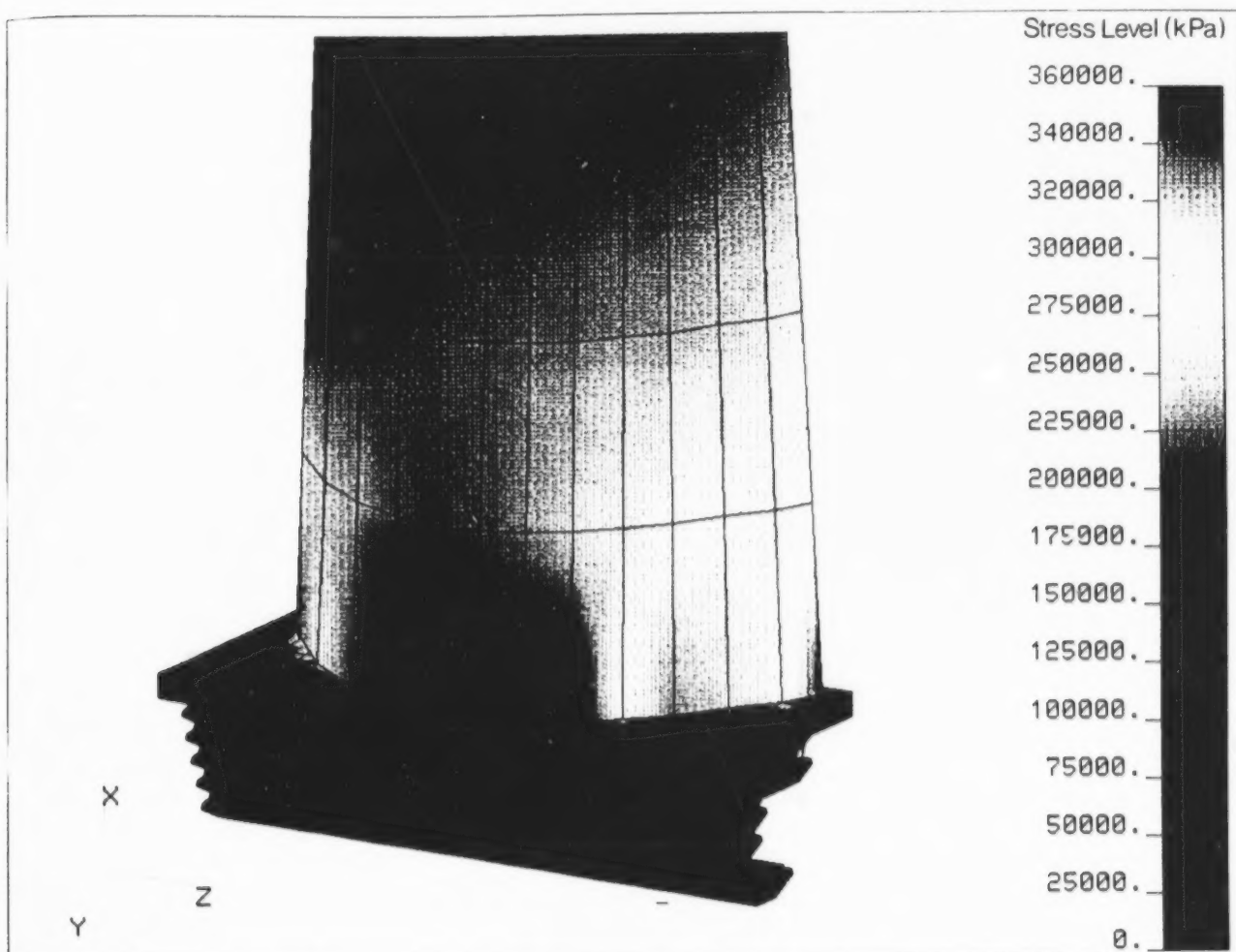
Dr. J.A. Chadha

Mechanical Testing
& Development

Mr. D.B. Craig

Nuclear Process
Components Test Facility
Dr. R.T. Hartlen

Plant Equipment Dynamics
Mr. T. Loewen



A stress analysis was conducted at Nanticoke on the root of a low-pressure turbine blade. The results of the analysis of the high stressed areas are shown here (indicated in red) and correspond to the regions where cracks in the root were found.

for unrelated reasons, were initiated. Data on the condition of conductors, overhead ground wires, insulators, hardware, towers, and footings are being obtained through field inspection, sample testing, and in-situ destructive tests on structures and foundations. The test program is aimed at the identification of mechanisms and rates of deterioration in different locations and the development of simple techniques of condition evaluation that can be applied in the field. The results will help prioritize candidate lines as part of a rational refurbishment program.

Plant Equipment Dynamics

Services and research performed by this Section focused on improving the reliability of plant equipment and reducing operating costs.

During the commissioning of units at Darlington NGS and other nuclear generating stations, vibration measurements and analyses performed on machinery, process equipment, piping systems, and structures contributed to the identification and resolution of a number of vibration-related problems. Similar problems in operating plants were investigated and corrected.

In generating stations, significant progress was made in the development and implementation of machinery condition monitoring systems. These systems provide information that allows the optimization of plant maintenance. Computer-based vibration monitoring systems, with portable data acquisition units and software customized to meet plant requirements, were implemented in Bruce NGS 'A', Darlington NGS, and the Bruce Heavy Water Plant. In addition,

an on-line monitoring and diagnostic system, developed for evaluating the condition of critical pump sets, was installed at Darlington NGS. Significant progress was made toward the development of a system for evaluating the condition of nuclear and fossil plant turbine generators. An EPRI-funded research project on condition monitoring of hydraulic generators was completed with the installation of two demonstration units.

Services were provided in controlling environmental and plant noise. High-voltage transmission line corona and transformer station noise have been investigated.

Mechanical Testing and Development

In addition to mechanical and structural testing the Section performs seismic and environmental qualifications

and conducts studies in tribology, fluid mechanics, heat and mass transfer, and two-phase flow.

The safe operation of aerial devices is of concern. In practice, this type of device is often subjected to a horizontal load because the conductor is supported by the device during line construction and maintenance operations. Thus, a load chart for a Pitman HS-50 aerial device has been developed that ensures that neither strength nor stability limits are exceeded under combined vertical and horizontal loads. A related development is a jib-load sensing device. The device ensures safe operation of bucket trucks and other aerial devices under all loading conditions.

Distribution class wood poles are being tested in our newly-developed fully-automated pole-test machine. The results are part of a program to compile a data base that will be used to formulate a rational and economical replacement program.

The seismic and environmental qualification program in support of Ontario Hydro's nuclear program continues. Items of electrical and mechanical equipment, mostly destined for Darlington NGS, were tested. Various sizes of masonry anchors from different manufacturers were seismically qualified, and load relaxation tests on masonry anchors were completed.

A CANDU pressure tube may sag and make contact with a calandria tube if the garter springs are displaced from their intended locations. This can cause the formation of hydride blistering and the consequent cracking of pressure tubes. Experiments were performed to measure the temperature field and to determine the effect of fretting in the contact area. This type of information is necessary because temperature gradient is the mechanism driving the migration of hydrogen.

Wear problems were investigated in the ball screw in the Bruce NGS 'B' fuelling machine and in the stopper liner in the Pickering NGS steam release valves. Lubricants were also assessed using ferrography.

Nuclear Process Components Test Facility

The Nuclear Process Components Test Facility's work program consists primarily of providing testing services to internal and external clients.



Seismic tests are being performed to verify that this air conditioning duct can withstand a seismic event without leaking. The air conditioning system, which cools critical equipment at Darlington NGS, has ducts designed with special flexible joints and is supported on rigid hangers.



Hot pressurized water flashes into steam and aerosol as it escapes from the nozzle. This pressurized-water "blowdown facility" is part of the program for modelling the aerosol behaviour of CANDU containment systems.

One highlight of 1987 was the construction, commissioning, and early operation of the new 'PV2' test facility. The purpose of this medium-scale test loop is to investigate process unsteadiness and piping vibration, that can occur under conditions of pumped two-phase steam-water flow. This situation may arise when the primary heat-transport circuit loses pressure due to a small leak. Results from this project will help safety analysts and piping designers analyze the depressurized circuit situation, determine operating limits, and assure piping integrity.

Service to external clients included the successful completion of a special test designed for another Canadian utility. This testing program provided information which led to the elimination of severe noise, vibration, and dynamic stresses caused by an orifice in the heat transport system. A mock-up of part of the system was con-



An articulated manikin is used in the testing of equipment designed to protect personnel from falls.

structed and connected to the main test loop for flow testing. The problem encountered in the plant was simulated, and a modified orifice assembly was developed. The laboratory test program was successful, the field application proven, and thus an operating limitation has been removed.

A new area of work is the qualification of components required to perform safety-related control functions under harsh environmental conditions which could be created by the release of either pressurized hot water or steam into a power plant. Environmental-qualification testing is performed in a separate facility equipped with various test chambers. During the past year, tests were performed on components such as solenoid valves, limit switches, and terminal boxes. Toward year-end, preparations were underway for a major steam-environment test of a heat-transport-pump circuit breaker.



Measurements are taken of the energy absorption properties of commercial vibration dampers for transmission lines. Unless controlled, wind-induced vibration of conductors and overhead ground lines lead to fatigue and wear of conductors and hardware, which causes increased maintenance and shorter service life. Better knowledge of damper properties is leading to more reliable performance of existing lines.

Applied Mechanics

The Applied Mechanics Section carries out research and development aimed at improving the reliability of the structures and equipment that make up Ontario Hydro's power system. In 1987, the Section was active in supporting the Corporation's nuclear and thermal generation, transmission, distribution, and nuclear waste management programs.

Analysis of zirconium hydride blister growth in reactor tubes was one important area of study. Build up of hydrogen and deuterium in pressure tubes can result in the formation of brittle deposits. Termed blisters, these deposits have an adverse effect on tube strength. Mathematical models were developed to predict hydrogen transport, blister growth, and to indicate the useful life of tubes under a variety of service conditions.

Construction has begun on a laboratory where pressure tests will be performed on large vessels and piping

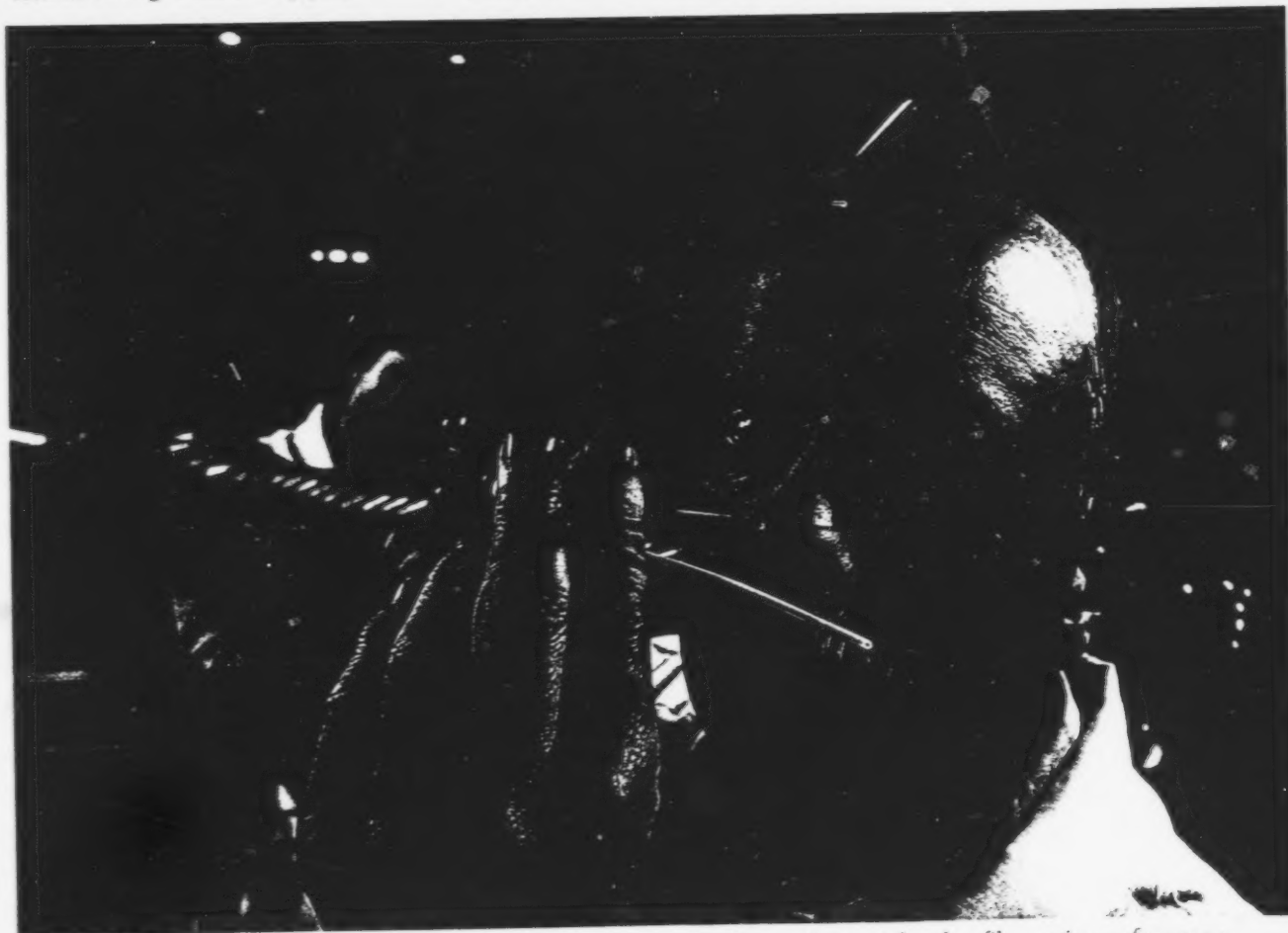
components. The facility is so designed that tests can be continued safely to the point of failure. The facility will be used to study the behavior of pressure vessels in extreme loading situations.

The Section is involved in the development of safe methods of transporting nuclear waste and performs tests on prototype containers. In 1987, a cask for road transportation of irradiated fuel, and packages for transporting operating wastes were tested.

Ontario Hydro is reviewing the feasibility of installing special ground wire cables on its transmission towers; these cables contain a bundle of optical fibres. The optical fibres, which are entirely immune from electromagnetic interference, can be used for telecommunications. The Applied Mechanics Section has built an experimental rig to evaluate the reliability of fibre-equipped cables under simulated service conditions. Cables from various manufacturers are currently under test.



Personnel observe drop tests of scale models of steel concrete casks performed to obtain data for the development of scaling parameters.



The vibration resistance and the mechanical properties of a novel overhead ground wire with a glass fibre optic core for use on high-voltage transmission lines are under study.

Manager's Report

The Metallurgical Research Department provides a resource comprising specialized facilities and advanced knowledge in physical metallurgy, materials science, and nondestructive testing. The work of the Department was dominated in 1987 by projects designed to meet the objective of maintaining the reliability of Ontario Hydro's CANDU nuclear units.

Hydrogen uptake by zirconium alloy pressure tubes is a life-limiting process. Corrosion processes, believed to be a major contributor to hydrogen uptake, were the subject of extensive study. Similarly, studies of the effect of hydride on the integrity of pressure tubes continued, particularly in the areas of delayed hydride crack initiation and growth, and blister formation. Other work impacting on fuel channel performance included deformation experiments and research into the limitations and applicability of nondestructive testing techniques for defect detection and evaluation.

METALLURGY

Manager

Dr. J. Brown

Senior Research Engineer

Dr. M.P. Dolbey

Corrosion & Tritium
Technology

Dr. P.C. Lichtenberger

Materials Integrity

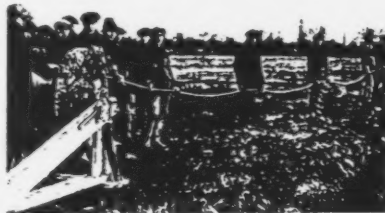
Dr. R.G. Fleck

Metallurgy

Dr. W.H.S. Lawson

Nondestructive & Fracture
Evaluation

Dr. J.A. Baron



"Paying-out" power cable in 1921.

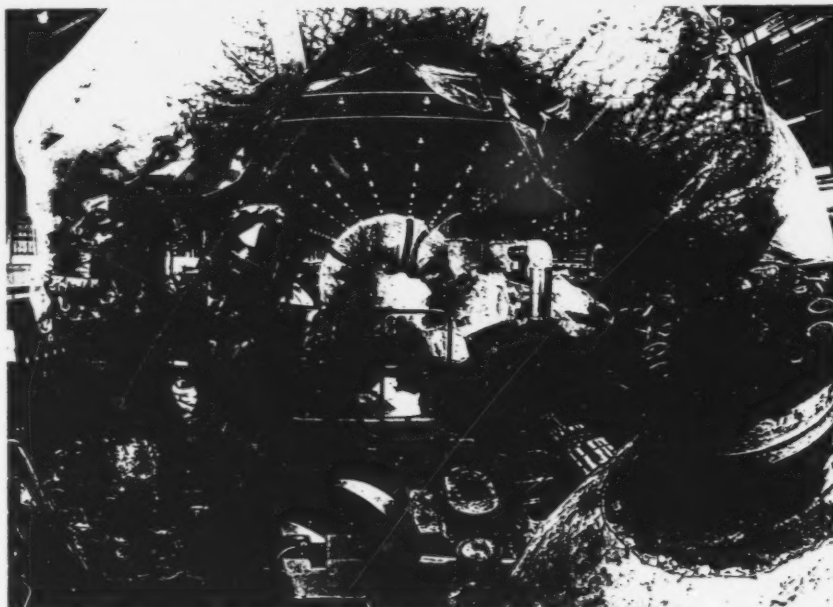
Other components of nuclear generating plant also received attention. Tube corrosion under sludge deposits is the most significant cause of failure in nuclear steam-generators worldwide; thus, the Research Division program focuses on the tube-sheet region of CANDU steam generators. In addition, fracture mechanistic studies showed that, if failure did occur in the large-diameter heat transport piping, it would be by a leak-before-break mode rather than by a catastrophic one. This finding contributed in part to the licensing of the Darlington Nuclear Generating Plant.

Research addressing the current needs of thermal plants centred in life assessment. Techniques for interpretation of microstructural changes that occur in key components operating at high temperature were developed and

used at Lakeview TGS. A project supported by the Canadian Electrical Association on robotic weld repair of hydraulic turbine runners saw the commissioning of a robot and advances in system software for automated welding.

Significant transfer of technology occurred, particularly in areas associated with tritium handling. Furthermore, the Department continues to provide a problem-solving service in the materials area, and a variety of problems involving failure analysis and corrosion were addressed. General consulting services and support for the development of a number of industry standards were maintained.

The Department's Senior Research Engineer continued his close collaboration with the Nondestructive Evaluation (NDE) Unit to further develop techniques and equipment for



In-situ metallography is being performed to assist in determining the remaining life of a turbine-loop pipe-weld at Lakeview TGS.

the assessment of the condition of zirconium alloy pressure tubes in CANDU nuclear reactors.

To ensure the use of defect-free pressure tubes, optimal manufacturing inspection is required. The record is good, but operational experience indicates room for improvement. Thus, work is underway in cooperation with the Nuclear Generation Division, Atomic Energy Canada Limited (AECL), and various tube manufacturers to identify and implement improved inspection equipment and procedures. These were used for inspecting tubes intended for use in the Darlington NGS Unit 4 reactor. A study of inspection signatures from acceptable new tubes was undertaken to determine their impact on interpretation of in-service inspection results.

There is a need for a nondestructive method of measuring the amount of hydrogen that exists in pressure tubes. A method developed by the Department's Materials Integrity Section is encouraging and is being adapted for use in our reactors.

Since the Channel Inspection and Gauging Apparatus for Reactors (CIGAR) system was conceived, the extent and the method of inspection techniques have changed radically. Consideration is now being given to a new inspection system able to operate independently of the main components of a reactor's fuel handling system.



In cooperation with researchers at IREQ, and with co-funding support from the CEA, a portable, compact robotic system is under development for the in-situ repair of cavitation damage in hydraulic turbine runners.

Metallurgy

In 1987, the Metallurgy Section initiated a major technology advancement through work on the robotic repair of hydraulic turbine runners. The project was performed in collaboration with the Institut de recherche d'Hydro-Québec and was funded by the Canadian Electrical Association. The robot has now been commissioned and is able to weld. More important is that the technology secured advances in system software, which include concepts of artificial intelligence and self-programming.

Among other applications, pulsed-gas metal-arc welding, which is the process of choice for turbine runner repair and for automated and manual pipe welding, has been the target of an intense reliability improvement program. Several types of characteristic defects were identified and the practical limits of the process defined for critical applications, such as in temper-bead welding.

The Section plays a central role in the development of the Corporation's welding standards. This is done by carrying out qualification testing and by arranging regulatory approvals for all standard welding procedures.

As a major centre for development of welding technology for spent nuclear fuel containment, the Section completed process definitions for all

container designs and materials currently under study.

Through its work on metallurgical failure analysis, the Section plays a major role in problem solving. Diagnosis of fatigue cracking of the moderator recirculation pipework at Pickering NGS Units 5 to 8; remediation of cell connector and cover defects in station batteries; discovery of a widespread quality problem in the manufacture of fuel injection nozzles of gas turbines on emergency generators; definition of a remedial program for flange stud fractures at the Bruce Heavy Water Plant; and evaluation of the condition of preemptively removed steam generator tubing were items dealt with during the past year.

The Section continues to give decision support in life assessment of fossil-fired generating units. Metallography based on replication offers the only nondestructive means of determining the status of components operating in the creep (high temperature) regime. For example, assessment work continues at Lakeview TGS. All the replication done in the field at Lakeview is now complete. Laboratory analysis of data obtained from Units 4 and 7 is in progress, while that for Unit 1 is complete. Life assessment evaluations have been performed on samples of boiler and condenser tubing that were removed preemptively. Whereas most components were in good condition, decisions regarding their replacement may become necessary in the near future.

Frequent failures of aluminum castings, invariably attributable to poor alloy selection or unacceptable foundry practice, led to the development and completion of a laboratory investigation of the problem. Dramatic improvements in the properties of small laboratory castings were demonstrated to be the result of merely careful attention to alloy and process control within normal working ranges. Client acceptance of this demonstration has been excellent. As of year end, a client-funded demonstration of our recommended practices is being carried out under our supervision in a local commercial foundry.

Corrosion and Tritium Technology

Corrosion of zirconium alloy pressure tubes and their subsequent hydrogen uptake provided a major area of study for the Corrosion and Tritium Technology Section. The life

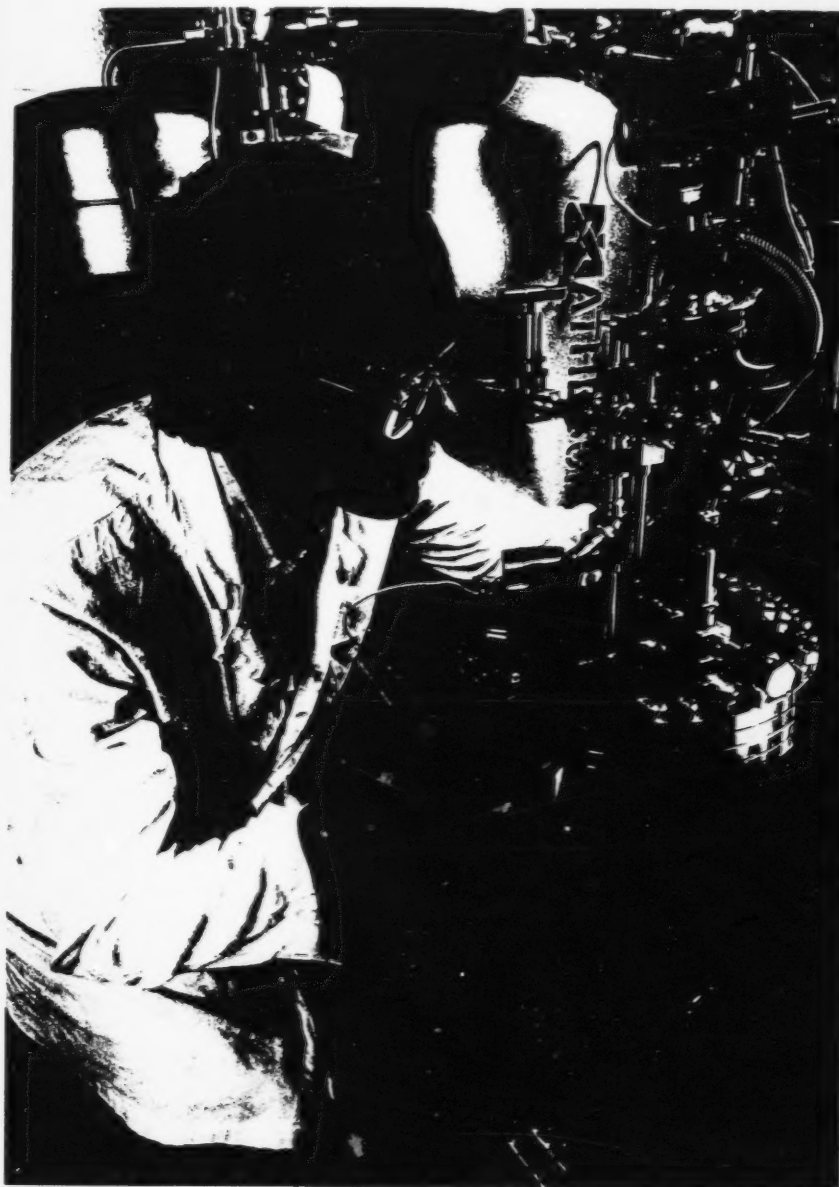


Strong aluminum castings with vastly superior ductility and fracture toughness properties were produced through cooperative research with Brampton Foundries.

of nuclear reactor pressure tubes is directly related to the rate of hydrogen uptake. The principle source of this hydrogen is believed to be associated with the waterside corrosion process. Thus, a program is underway to quantitatively establish the influence of the key parameters of temperature, water chemistry, oxide characteristics, surface condition, and alloy and impurity effects. Both normal and accelerated testing are being used. To simulate the end-of-life condition of oxides on reactor pressure tubes, thick oxides, grown artificially on test coupons, have been produced and installed in fuel bundles in several CANDU reactors to generate a base of reactor-relevant data.

Detailed characterization of the oxide, the metal-oxide interface, and the bulk alloy allows correlation of the results of parametric exposure testing and of corrosion and hydrogen uptake measurements. Intermetallic formation, other reactor operation-induced microstructural changes, and the development of oxide porosity, cracking, and spalling are being studied to establish rate controlling processes for the hydrogen uptake mechanism.

Predictive modelling based upon parametric functional relationships is under development. Predictions have already been generated to assist the planning of Repositioning of Endfittings and Bearings (REFAB) and Spacer Location and Repositioning



A uranium-hydride storage bed has been developed for the temporary storage of tritium at Darlington NGS. Using three kilograms of depleted uranium, the beds have a rated storage capacity of 52 grams (500 kCi) of tritium.

(SLAR), and the making of decisions to retube.

Corrosion of nuclear heat exchangers and steam generator tubing provides another fertile area of investigation. Heat-exchanger test rigs are in operation at the Pickering and Darlington Nuclear stations to study localized corrosion initiation and propagation effects using Lake Ontario water as a function of tube deposit buildup, microbiology, and tube material. The rigs facilitate realistic testing of remedial measures, which include chemical cleaning and biociding. Laboratory immersion and electro-

chemical simulation tests are used to gain further understanding of corrosion degradation processes. Initiation probability and propagation rates in lakewater have already been determined for a number of alloys in current use.

In pressurized water reactors, steam generator tubing is susceptible to stress corrosion cracking, localized corrosion under sludge deposits, and corrosion fatigue. To predict the susceptibility of CANDU to these mechanisms, exposure testing using laboratory simulations is being carried out to establish a data base applicable to CANDU

operating variables. Temperature, alloy heat treatment, and water chemistry are considered key factors.

Tritium technology is another significant interest of the Section. A hydrogen pump, which relies on the permeation of atomic hydrogen through bilayer metal membranes, has been developed. This equipment features high pumping rates at high compression ratios. A potential commercial application is to fusion reactor systems which are required to pump tritium and to purify fuel and exhaust streams. The concept is also being tested as a diagnostic probe on the TEXTOR tokamak to measure hydrogen fluxes under various operating conditions.

The safe management of tritium requires that it be stored under well-controlled conditions. Metal getter research has progressed sufficiently to permit efficient immobilization of tritium on uranium and zirconium-iron beds. High performance, doubly-contained storage beds of 25g and 3,000 g size were designed, constructed, and tested to measure hydriding rates under a variety of conditions. The 3,000 g beds were commercialized and installed at the Darlington Tritium Recovery Facility (TRF). The technology also has commercial potential for processing fusion reactor exhaust systems and for purifying inert gas glovebox environments.

Technical support to the Darlington TRF included leak testing calibration, tritium monitor testing, and assistance with operating manual documentation. Final operational commissioning of the tritium immobilization system is underway. Consultation services have been made available to the University of Rochester and to Hydro's own Tritium Application Program.

Materials Integrity

The Materials Integrity Section has been extensively involved in the study of delayed hydride cracking, pressure tube fracture, and the effects of irradiation on the deformation performance of standard and modified pressure tubes.

Studies on the influence of hydrides on pressure tube performance focused on delayed hydride crack initiation and growth, and on blister formation and cracking. Of significance is the development of a probabilistic model that is able to assess the state of the

core of a reactor with respect to blister formation and cracking that may be initiated when pressure tube-to-calandria tube contact occurs. This work has been accepted as a key predictor of the occurrence of blister problems in Pickering NGS Units 3 and 4. Further work in this area evaluated the movement of hydrogen under fret marks which developed in the commissioning of Pickering NGS Unit 8. It was demonstrated that hydrogen moves away from these marks. From this observation, the Atomic Energy Control Board deferred tube removal to permit hydride distribution at fret marks to be established.

In the evaluation of pressure tube integrity, a key factor is knowledge of the hydrogen concentration in the tubes. A technique for the nondestructive in-situ measurement of hydrogen concentration has been developed in the laboratory. Hydrogen concentration is determined by detecting changes in resistivity with temperature variation; the phenomenon has been successfully demonstrated in small specimens and on a section of a pressure tube.

Irradiation growth tests on pressure tube materials continued in the DIDO reactor at the Atomic Energy Research Establishment at Harwell, UK because the neutron flux in this reactor is higher than in the CANDU. Test specimens in the DIDO reactor have exceeded the neutron fluence of pressure tubes in the CANDU reactor with the longest service. Power reactor deformation data have been analysed and compared with the predictions of design equations. Of particular importance was the modelling of pressure tube-to-calandria contact in relation to the time-to-contact and the location of the contact.

In support of safe reactor operations, a program to establish handling criteria of partially oxidized fuel cladding has been carried out. The mechanical strength of the cladding was established by post-oxidation tensile tests at ambient temperatures and by biaxial deformation during the oxidation process. These criteria will be used to inform operations staff about the potential risk of fuel clad failure when handling partially oxidized fuel cladding.

Nondestructive and Fracture Evaluation

Fracture mechanistic studies were

used extensively in the Darlington NGS leak-before-break project. The objective was to demonstrate that large-diameter, primary heat-transport piping would, if subject to failure, fail in the leak-before-break mode rather than in the sudden guillotine or other mode. This program encompasses significant elements of material testing with an emphasis on weldments and zones affected by heat, and analytical elastic-plastic fracture mechanics. The project has generated excitement on an international scale, primarily in Japan and the United States. If this project had failed to realize its objective, the licensing of the Darlington station would have been jeopardized.

Work in the Nondestructive Evaluation Unit was directed at fuel channel inspection capability. The Unit had significant involvement in the Package Inspection Probe for Rolled Joint Evaluation (PIPE) project which in one week was successfully commissioned and utilized to inspect 110 rolled joints in Bruce NGS Unit 2. Work on the Pickering version of PIPE has been extended to allow rapid inspection for the location of garter springs and blisters. Significant assistance has been provided to Central Nuclear Service to upgrade Channel Inspection and Gauging Apparatus for Reactors (CIGAR) capability. This has involved integration of a computer, an optical disc, and new software, which replace the original gauging system and the flaw detection data system. Further development of curved-line focused probes for the SLAR system has been undertaken.

Other fuel channel-related activity has been aimed at investigating various approaches to hydride platelet concentration measurement and the estimation of blister crack depths. A technique for hydride platelet measurement readily adaptable to fuel channels has not yet been discovered, but the application of scanning acoustic microscopy looks promising.

Ultrasonic crack tip diffraction signals have been processed according to time of flight, and in thick pressure boundary material, synthetic aperture techniques yield excellent estimates of defect position and size. This advancement is essential in the fitness-for-purpose analysis of pressure boundary components as it enables reasonable precision in the sizing of defects.

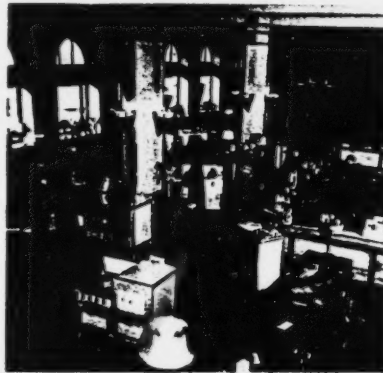
Manager's Report

The Department provided ongoing services to numerous Corporate clients. The client base and the range of services has been expanded in the areas of operations research, statistics, and power system reliability. Specialized computer support services were provided to research staff.

Operations Research

Operations Research (OR) is a label coined in WW II to describe the scientific analysis of military operations. Since then, the term has been widely used in business, industry, and government. For over 30 years, the services of operations researchers have provided clients in Ontario Hydro with practical and cost-effective solutions to a variety of problems. In 1987, the OR Unit focused its efforts on operational efficiency enhancement for clients. During a year marked by significant diversification in areas of applications, it has provided problem-solving services and has developed decision support systems for ten Hydro Divisions. In anticipation of the needs of the Corporation, the OR Unit continued to enhance its capability in expert systems with the development of two prototypes: one for a signing authority register, the other for literature searches.

The Computer Support Unit continued to provide specialized programming and consulting services to the staff of the Research Division. The Unit also increased its efforts in the research, evaluation, and introduction of new computer technologies. In 1987, a workstation designed to run true three-dimensional Computer-Aided Design and Drafting applications was evaluated and acquired. Facilities were purchased and installed



A scene from the Hydro Shop of the London Public Utility Commission in 1944.



Operations Research personnel discuss how a microcomputer might resolve a scheduling problem.

for desk-top publishing and presentation graphics. To enhance file transfer and sharing of resources, a local area

network was acquired for the computer room. The Research Division's Integrated Computing Environment (ICE) Planning Project was successfully completed under leadership provided by the Section. The recommendations of the ICE Planning Project were endorsed by the Research Executive.

OPERATIONS RESEARCH

Manager
Mr. J.G. Cassan

Operations Research
Dr. A.H. Chung
Reliability & Statistics
Dr. J. Endrenyi

Reliability and Statistics

For many years, the Reliability Unit of the Section has been involved with the development of mathematical models of system reliability and their applications. The aim of this work is to assist Hydro's planning, operating, design, and maintenance functions. Typical projects undertaken by the Unit this year were the development of



Our highly skilled statisticians are always ready to resolve client problems.

a much needed method for estimating confidence bounds for a Monte Carlo simulation program used by the Power System Operations Division and a reliability assessment of the control and operating facilities to be installed at the new System Control Centre at Clarkson.

Reliability Unit staff have earned an international reputation through publications and participation in committees and conferences. This year, staff gave seminars in China and Israel, and participated in a workshop sponsored by the National Science Foundation. Staff participated in a CIGRE

project which produced an application guide for power system reliability analysis.

The Statistics Unit was formed several years ago when a Corporation-wide need for expert assistance in data collection and evaluation was perceived. Such assistance appeared to be most welcome when interpretations had to be made of data that were scarce, interrelated, dispersed, or even contradictory. The Unit's reputation is now well established both inside and outside the Division.

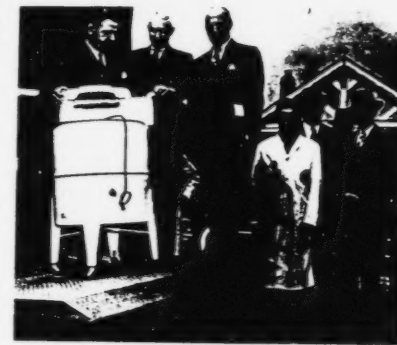
Studies, typical of the diversity of

projects taken up by the Unit, include a proposal for a national sampling plan for revenue meters, which was developed under a Canadian Electrical Association contract; a statistical evaluation of the error in estimates of reactor channel powers; a forecast of Niagara River flows; the identification of relationships among performance and cost indicators for all sources of energy production; and the estimation of hot water system sizes for multi-residential buildings. In addition, assisting clients through informal consultations continued to be a daily part of the Unit's activities.

DIVISIONAL SERVICES

The Divisional Services department provides support to the whole Division. These services include report production; business administration; financial reporting; records, space, and safety management; printing and clerical services; model shop production; drafting; photography; payroll; and editorial services.

This year a Strive For Excellence Program was initiated. The vision statement is as follows: "We intend to be an excellent service unit that helps the Division to do its work better. We strive for excellence in service to our customers through the commitment and the abilities of our people." The four values of the Strive For Excellence Program are excellent performance, customer satisfaction, respect for people, and reasonable service costs. Highlights of the program included a one-day seminar for section heads, publication of a services and standards manual, recognition for extraordinary performance, emphasis on employee safety, the use of rotations for staff development, better staff



In May 1944, Hydro officials check a washing machine converted to operate on 60-Hertz service as part of the Frequency Standardization Program.

communications, and better monitoring of costs.

The Department's capability was extended, notably in the Model Shop and Drafting Office. New machines have enabled the Model Shop to produce higher quality work and to concurrently improve productivity. The use of computer-aided drafting has increased drafting productivity. In addition, the photography section is upgrading its capability, particularly in video recording techniques.

The Integrated Computing Environment Planning Project was completed and Divisional Services is now supervising its implementation. The aim of this project is to link computers and other electronic equipment throughout the Division. The capabilities of researchers will be enhanced by improving client interactions, by allowing access to more comprehensive decision-making information, and by allowing new work to be under-

taken that was not previously economically feasible. Costs will be reduced by electronic storage of information, sharing hardware and software, and more cost-effective information processing.

Other highlights were the production of the Research Division's Business Plan and the development of a plan to improve the Divisional management of records. The Drafting Office and the Photography Section made major contributions to the Division's 75th Anniversary celebration through the provision of artwork and photographs, which were used throughout the Division.

The Model Shop utilized their new capabilities to make a notable contribution to the Spacer Location and Repositioning (SLAR) program by successfully undertaking the production of 50 high-performance coils for fuel-channel spacer relocation, thereby permitting Ontario Hydro to meet all AECL's scheduling requirements.

DIVISIONAL SERVICES

Manager
Mr. J.B. Brown

Business Administration
Mr. G.E. Craig

Drafting
Mrs. W. Zwolakowski

Research Publications
Dr. G.R. Floyd

Information Management
Mrs. C. Moraes

Model Shop
Mr. C.P. Stearns

Photography
Mr. K.R. Buck



Prototyping nuclear inspection heads at the Research Machining Facility.

RESOURCES AND COSTS

At the end of 1987, the Division's personnel resources consisted of a total regular staff of 649. The percentages of funds allocated to major work programs, the application of staff in various categories of work (Divisional Services Department excepted), and the distribution of staff in broad occupational classes are shown below.

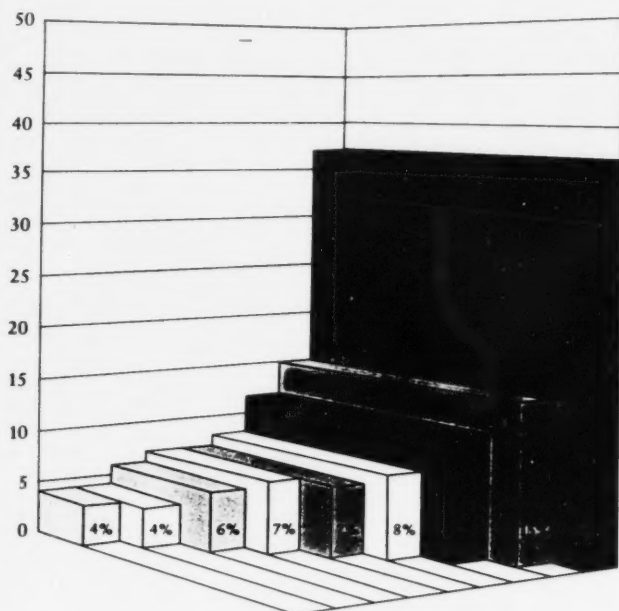
The total of all costs, including those for space, materials and equipment for work done by the Research Division in 1987 was approximately \$57.6 million.

Costs were met or allocated as follows:

Revenue from work done for other organizations	\$ 4.4 M
Transfers to other Ontario Hydro Branches	\$27.5 M
Transfers to the Cost of Power	\$25.7 M

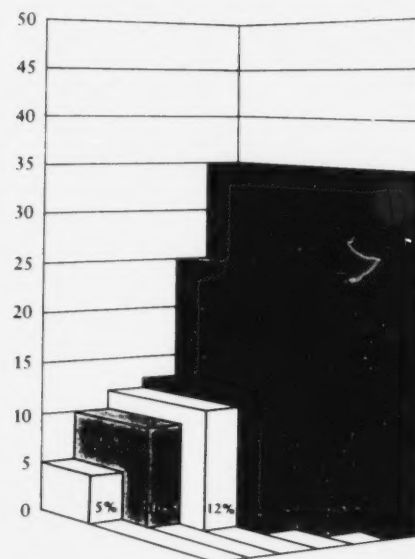
**Research Division Programs for 1987 –
Proportions by Actual Gross Costs**

- General Research Programs
- Utilization
- Electric Power Systems
- Transmission Systems
- Distribution Systems
- Nuclear Generation
- Nuclear Waste
- Thermal and Hydraulic Generation
- Environmental



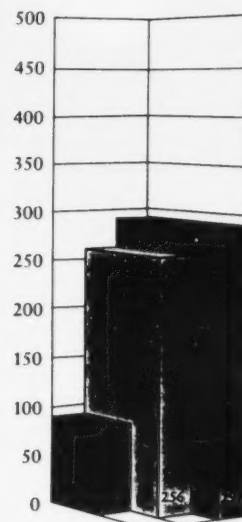
**Proportions of Total Salary Costs for
Various Categories of Work**

- Testing
- Consultation
- Technical Investigation
- Research & Development, Present Needs
- Research & Development, Future Needs
- General



**Occupational Classification of
Research Division Staff**

- Management & Professional
- Technicians & Technologists
- Support Staff



- Abdul-Razzak, A., Chan, A.M.C., and Shoukri, M.
"Modelling Aspects of the Rewetting of Horizontal Tubes",
Second Workshop on Advanced CANDU Reactor
Thermalhydraulics, October 1987, Hamilton, Ontario.
- Amm, D.E.: see Bellamy, G. *et al.*
- Anderson, H.L., and Forest, J.W.
"Vibration Monitoring of Heat Transfer Equipment and Piping
Systems in Operating CANDU Stations", International
Conference on CANDU Maintenance, November 22-24, 1987,
Toronto, Ontario.
- Anyas-Weiss, N.
"Enrichment and Utilization of C-14", University of Toronto,
May 6, 1987, Toronto, Ontario.
- Arora, H.S.*: see Dayal, R. *et al.*
- Arron, G.P.
"Effect of Trunk Injection of Growth Regulators on Silver Maple -
Second Year Data", Second Annual Tree Growth Regulator
Symposium, March 9-12, 1987, Destin, Florida.
- Ash, P.O.: see Chan, H.T. *et al.*
- Azizian, H., and Braun, J.M.
"Gas-in-Oil Analysis as an Acceptance Criterion during
Transformer Factory Overload Testing", CEA Engineering and
Operating Division Meeting, March 23-24, 1987, Vancouver,
British Columbia.
- "Analysis of Trace Byproducts from Overheated Paper Insulation
in Power Transformers", CEA Engineering and Operating
Division Meeting, March 23-24, 1987, Vancouver, British
Columbia.
- Balbua, I., Chu, F.Y., Greening, F., Mannik, L., and Mayer, P.
"Characterization of High Temperature Superconductor
YBa₂Cu₃O₇ and SmBa₂Cu₃O₇", University of Western Ontario
Workshop on High Temperature Superconductor, September 11,
1987, London, Ontario.
- Bellamy, G., Nashid, M.S., and Amm, D.E.
"Failure of Hardware on a key 345 kV Span Across the St. Clair
River", CEA Engineering and Operating Division Meeting, March
23-24, 1987, Vancouver, British Columbia.
- Bernstein, B.S.*: see Stone, G.C. *et al.*
- Boag, J.M., and Flaman, M.T.
"Comparison of Hole Drilling Residual Stress Analysis
Techniques", Society of Experimental Mechanics Spring
Conference, Houston, Texas.
- Boag, J.M., Flaman, M.T., and Herring, J.A.
"Considerations of Using the Hole Drilling Method for Measuring
Residual Stresses in Engineering Components", American Society
of Metals Conference: Residual Stress in Design, Process and
Material Selection, April 27-29, 1987, Cincinnati, Ohio.
- Boeck, W.*: see Wiegart, N.* *et al.*
- Boggs, S.A.: see Fujimoto, N. and Wiegart, N.* *et al.*
- Boyd, J.M.
"Monitoring for Predictive Maintenance in Hydropower
Plants-Experience and Conclusions", Fourteenth Inter-Ram
Conference, May 27-28, 1987, Toronto, Ontario.
- *denotes other than Ontario Hydro employee
- Boyd, J.M., and Koehler, H.P.
"Monitoring for Predictive Maintenance: A Recommendation for
Hydropower Plants", CEA Engineering and Operating Division
Meeting, March 23-24, 1987, Vancouver, British Columbia.
- Braun, J.M.
"Leak Detection for Nuclear Containment", CANDEV
Symposium, January 12, 1987, Mississauga, Ontario.
- "Effects of Thermal Envelope Upgrading on Electrical Wiring
Systems", ASTM Symposium on Insulating Materials, Testing and
Applications, December 6, 1987, Bal Harbour, Florida.
- see also Azizian, H.; Chu, F.Y.; and Zeya, M. *et al.*
- Brede, C.K.*: see Lloyd, B.A. *et al.*
- Brinkley, J.W.: see Sulowski, A.C.
- Brown, D.
"Growth of Stump Sprouts on a Simulated Right-of-Way", Fourth
Symposium on Environmental Concerns in Rights-of-Way
Management, October 25-28, 1987, Mississippi, USA.
- Brown, S.K.: see Mannik, L. *et al.*
- Campbell, S.R.: see Mannik, L. *et al.*
- Carey, W.E.: see Griffiths, J.S. *et al.*
- Causey, A.R., Woo, C.H., and Holt, R.A.
"The Effect of Intergranular Stresses on the Texture Dependence of
Irradiation Growth of Zirconium Alloys", International
Workshop on Fundamental Mechanisms of Irradiation Creep and
Growth, June 1987, Hecla, Manitoba.
- Cenanovic, M., Ng, M., Lee, J., and Malkiewicz, T.
"Rolled Joint Separation by Shock Heating", International
Conference on CANDU Maintenance, November 22-24, 1987,
Toronto, Ontario.
- Chadha, J.A., and Strickert, R.J.
"Assessment of Plant Life Extension and Long-Term Reliability
Assurance Issues for Ontario Hydro's Nuclear Generating
Stations", Twenty-seventh Annual Conference of the
CNA/Eighth Annual Conference of the CNS, June 14-18, 1987,
St. John, New Brunswick.
- Chadha, J.A., Daly, I.N., and MacTavish, B.D.
"Nuclear Plant Life Assurance Program for Ontario Hydro's
Nuclear Generating Stations", International Conference on
CANDU Maintenance, November 22-24, 1987, Toronto,
Ontario.
- Chan, A.M.C.: see Elphick, I.G.; Abdul-Razzak, A. *et al.* and
Lam, T. *et al.*
- Chan, H.T., and Cragg, C.B.H.
"Geotechnical Challenges Associated with Increasing the Storage
Capacity of a Coal Ash Lagoon", Eighth International Coal Ash
Utilization Symposium, October 28-31, 1987, Washington, DC.
- Chan, H.T., Sykes, J.F.*, and Ash, P.O.
"Computer-Aided Design Approach for Fly Ash Landfills", Eighth
International Coal Ash Utilization Symposium, October 28-31,
1987, Washington, DC.
- Chengji, L., Perovic, V., and Purdy, G.R.
"Observations of the Bainite/Austenite Interface in Steels", Phase
Transformations 87 - International Conference on Phase
Transformations in Solids, July 6-10, 1987, Cambridge, England.

Cherney, E.A.

"The Electrical Performance of Polymeric Insulating Materials under Accelerated Aging in a Fog Chamber", IEEE PES Winter Meeting, February 1-6, 1987, New Orleans, Louisiana.

"Long-Term Mechanical Life Testing of Polymeric Post Insulators for Distribution and a Comparison to Porcelain", IEEE Summer Power Meeting, Paper # 87 SM 551-5.

Chisholm, W.A., and Janischewskyj, W.*

"Rationalization of Lightning Flash Counter Measurements", Fifth International Symposium on High-Voltage Engineering, August 24-28, 1987, Braunschweig, West Germany.

Cho, H.R.*, Iribarne, J.V.*, Soong, S.T.*, and Melo, O.T.

"An Eulerian Model of Long-Range Transport of Air Pollutants and Acid Rain", Technology Transfer Conference, November 30-December 1, 1987, Toronto, Ontario.

see also Melo, O.T. *et al.*

Chow, C.K.: see Manolescu, A.V. *et al.*

Chu, F.Y.

"Tracking Resistance and Arc Degradation Resistance of Epoxy Insulators in GIS", IEEE Insulation Society Toronto Chapter, April 29, 1987, Toronto, Ontario.

"Applications of High Transition Temperature Superconductivity Materials in Electric Power Systems", NRC Superconductivity Industrial Meeting, April 30, 1987, Toronto, Ontario.

"Thermal Efficiency of 80-kW DC Plasma Torch", Eighth International Symposium on Plasma Chemistry, August 31, 1987, Tokyo, Japan.

"An Investigation of the Product Gases Formed by Coal Powder and Steam Injection in Plasma Flame", Eighth International Symposium on Plasma Chemistry, August 31, 1987, Tokyo, Japan.

"Recent Developments in High Temperature Superconductivity", CEA Engineering and Operating Division Meeting, October 19, 1987, Edmonton, Alberta.

"The Material Aspect of Gas Insulated Equipment: Aging, Decomposition and Diagnostics", Fint Brazilian Electrical Material Seminar, December 1-4, 1987, Curitiba, Brazil.

see also Balbaa, I. *et al.*

Clinton, J.*: see Dayal, R. *et al.*

Colman, J.E.*, Kalia, R., and Dodd, D.J.R.

"Electrochemical Synthesis of Ethylene Glycol - Design of a 12 kg/h Pilot Plant", First International Forum on Electrolysis in the Chemical Industry - Synthesis and Pollution Control, November 11-13, 1987, Deerfield Beach, Florida.

Cragg, C.B.H., and Krishnasamy, S.G.

"Probabilistic Analysis of Transmission Tower Foundations in Clay", Fifth International Conference on Applications of Statistics and Probability in Soil and Structural Engineering, May 25-29, 1987, Vancouver, British Columbia.

see also Chan, H.T. *et al.*

*denotes other than Ontario Hydro employee

Crawford, A.M., Radhakrishna, H.S., and Lau, K.C.

"Application of Integrated Finite Difference Technique to Heat Transfer Through Unsaturated Particulate Media", Fifth International Conference on Numerical Methods for Thermal Problems, June 29 - July 3, 1987, Montreal, Quebec.

Croall, S.J.: see Fujimoto, N. *et al.*

Csillagi, E.G.: see Manolescu, A.V. *et al.*

Currie, I.G., Havard, D.G., and Pon, C.J.

"Literature Survey on Aeolian Vibration Excitation of Bundled Conductors", CEA Engineering and Operating Division Meeting: Conductor Vibration and Oscillation Subsection, March 23-24, 1987, Vancouver, British Columbia.

Daly, I.N.: see Chadha, J.A. *et al.*

Dalziel, B.P.: see Krasznai, J.P. *et al.*

Dayal, R.

"C-14 Attenuation in Cement-Based Materials", Ontario Hydro / AECL Workshop on C-14 Research, November 1987, Chalk River, Ontario.

Dayal, R., and Klein, R.

"CO₂/Grout Interactions and their Relevance to C-14 Attenuation in Cementitious Backfill Materials", International Conference on Chemistry and Migration Behaviour of Actinides and Fission Products in the Geosphere, September 1987, Munich, West Germany.

Dayal, R., Klein, R., and Jakubick, A.T.

"Carbon-14 Attenuation in Cementitious Backfill Materials", International Conference on Chemistry and Migration Behaviour of Actinides and Fission Products in the Geosphere, September 1987, Munich, West Germany.

Dayal, R., Milian, L.*, Clinton, J.*, and Arora, H.S.*

"Effect of Wet / Dry Cycles on the Leaching of Cemented Waste Forms", Symposium on Leaching Tests for Radioactive and Chemically Hazardous Waste Forms: Mass Transport and Chemical Reactions, American Chemical Society National Meeting, August 1987, New Orleans, Louisiana.

Deans, J.J.

"Evaluation of Low Temperature Anchor and Bearing Pad Materials for Towerline Construction", ACI Seminar, February 1987, Toronto, Ontario.

"Evaluation of Magnesium Phosphate Concrete for Constructing Bearing Pads for Towerline Construction", Concrete Repair Seminar, July 1987, Cleveland, Ohio.

see also Mukherjee, P.K. *et al.*

Dhirani, H.: see Dick, E.P. *et al.*

Dick, E.P., Dhirani, H., Gupta, B.K., Powell, P.W.*, Shinn, R.A.*, Greenwood, A.*, and Porter, J.W.*

"Review of Generator Surge Coordination including Generator Breakers", IEEE PES Winter Power Meeting, February 1987, paper 87 WM 216-5, New Orleans, Louisiana.

Dodd, D.J.R.: see Colman, J.E.* *et al.*

Edwards, G.C., Northrup, F.J., and Thurtell, G.*

"Measurement of Dry Deposition Fluxes of SO₂ and NO₂ to a Forest Canopy Using a Diode Laser Spectrometer", Eighteenth Conference on Agricultural and Forest Meteorology, September 15-18, 1987, West Lafayette, Indiana.

Edwards, G.C., Wright, S.C., Kirshak, D.N., and Laratta, E.
"Evaluation of Regulation 308 Models with Site Specific Data",
Joint Annual Conference of Pollution Control Association and Air
Pollution Control Association of Ontario, April 5-7, 1987,
Toronto, Ontario.

Elphick, I.G., and Chan, A.M.C.
"Initially Subcooled Critical Discharge Through a Converging
Nozzle", Second Workshop on Advanced CANDU Reactor
Thermalhydraulics, October 1987, Hamilton, Ontario.

Endrenyi, J.
"Bulk Power System Reliability Concepts and Applications", Task
Force Presentation at the IEEE PES Winter Power Meeting,
February 1987, New Orleans, Louisiana.

"Bulk Power System Reliability Indices and Criteria", IEEE PES
Winter Power Meeting, February 1987, New Orleans, Louisiana.

"Power System Reliability - Challenges for the Future", National
Science Foundation Workshop on University Research for Electric
Power System Engineering, April 8-10, 1987, Tempe, Arizona.

"Developments in Power System Reliability - A Review", Israel
Electric Corporation, October 19-22, 1987, Haifa, Israel.

Erven, C.C.
"Surge Protection Practices", Ontario Hydro Course on System
Aspects of Protective Relaying, April 21, 1987, Toronto, Ontario.

Ewing, H.A.: see Krishnasamy, S.G. *et al.*

Ferrie, J.S.: see Gonzalez, L.A.

Flaman, M.T.: see Boag, J.M.

Fleck, R.G., Holt, R.A., Perovic, V., and Tadros, J.
"Effects of Temperature and Neutron Fluence on Irradiation
Growth of Zr-2.5 wt% Nb", International Workshop on
Fundamental Mechanisms of Irradiation Creep and Growth, June
1987, Hecla, Manitoba.

Forest, J.W.: see Anderson, H.L.

Foster, J.: see Oda, S.J. *et al.*

Foty, S.M.*: see Fujimoto, N. *et al.*

Fujimoto, N., and Boggs, S.A.
"Characteristics of GIS Disconnector-Induced Short Risetime
Transients Incident on Externally Connected Power System
Components", IEEE PES Winter Power Meeting, February 1987.

Fujimoto, N., Croall, S.J., and Foty, S.M.*
"Techniques for the Protection of Gas-Insulated Substation to
Cable Interfaces", IEEE PES Summer Meeting, July 1987.

Gallimberti, I.*: see Wiegart, N.* *et al.*

Gonzalez, F., and Trass, O.*
"A Shock Tube Study of the Pyrolysis of Nitric and Nitrous
Oxides", Sixteenth Shock Tube and Wave Symposium, Aachen,
West Germany.

Gonzalez, L.A., and Ferrie, J.S.
"Field Determination of PCB in Groundcover", EPRI PCB
Seminar, October 6-9, 1987, Kansas City, Missouri.

see also Zeya, M. *et al.*

Greening, F.: see Balbaa, I. *et al.*

Greenwood, A.*: see Dick, E.P. *et al.*

Griffiths, J.S., Carey, W.E., and Maher, J.F.B.
"Effects of a Great Lakes Generating Station Thermal Discharge
on Development and Survival of Round Whitefish Eggs - A
Combined Laboratory and Field Study", Fourteenth Annual
Aquatic Toxicity Workshop, November 1-4, 1987, Toronto,
Ontario.

Gupta, B.K.
"Surge Aging of Interturn Insulation", Cage Club Meeting, May
11, 1987, Ottawa, Ontario.

"Generator Insulation Aging and Test Methods", CEA, October
18-21, 1987, Edmonton, Alberta.

"Effects of Potential Surges on Motor Insulation", 1987 Joint
Power Generation Conference, October 4-8, 1987, Miami,
Florida.

see also Dick, E.P. *et al.*

Hardie, M.W.: see Warr, B.D. *et al.*

Hatanaka, G.K.
"Television Interference Location", Ontario Hydro Course, May
4-7, 1987, Orangeville, Ontario.

Havard, D.G., and Pon, C.J.
"Galloping Conductor Research in Canada 1986-1987", CIGRE
WG22-11 Task Force on Galloping, September 27-30, 1987,
Cleveland, Ohio.

"Literature Survey on Aeolian Vibration Excitation of Bundled
Conductors", CEA Engineering and Operating Division Meeting
Conductor Vibration and Oscillation Subsection, March 23-24,
1987, Vancouver, British Columbia.

see also Currie, I.G. *et al.*

Hawthorne, S.H., and Ruddick, J.N.R.*
"Development of an Environmentally Acceptable Wood Pole
Groundline Treatment Formulation", Eighth Annual Meeting of
the Canadian Wood Preservation Association, November 3-4,
1987, Vancouver, British Columbia.

see also Nguyen, Y.V. *et al.*

Heics, A.G., Shmayda, W., and Kherani, N.P.
"Heat Transport in Doubly Contained Uranium Storage Beds",
Thirty-Fourth AVS National Symposium, November 1987,
Anaheim, California.

see also Shmayda, W. *et al.*

Herring, J.A.: see Boag, J.M. *et al.*

Holt, R.A.
"Mechanisms of Irradiation Growth of Zirconium Alloys",
International Workshop on Fundamental Mechanisms of
Irradiation Creep and Growth, June 1987, Hecla, Manitoba.

see also Causey, A.R. *et al.* and Fleck, R.G. *et al.*

Hooton, R.D., and Sturup, V.R.
"Testing Aggregates for Long-Term Performance in Concrete",
Proceedings of the ASTM C-9 Symposium on Concrete Problems,
June 1987.

Husain, A.

"Development of a Gamma Spectrometry System for In-Situ Measurement of Radioactivity within Piping", International Conference on CANDU Maintenance, November 22-24, 1987, Toronto, Ontario.

Iribarne, J. V.: see Cho, H.R. * *et al* and Melo, O.T. *et al*.

Jakubick, A.T.: see Dayal, R. *et al*.

Jalbert, R.A.: see Kherani, N.P. *et al*.

Janischewskyj, W. *: see Chisholm, W.A.

Jarv, T.

"Studies of H₂S and SO₂ Adsorption / Chemisorption by Respirator Canisters", 1987 Conference of the International Society for Respiratory Protection, October 18-22, 1987, Toronto, Ontario.

see also Melo, O.T.

Jervis, R.E. *, and Pringle, T.G.

"Contributions from Industrial and Municipal Sources to Airborne Heavy Metal Particulates", Sixth International Conference on Heavy Metals in the Environment, September 1987, New Orleans, Louisiana.

Jones, W.R.

"The Effect of an Improved Window on Condensation Potential", BTECC / DOE Symposium on Guidelines for Air Infiltration, Ventilation, and Moisture Transfer, Fort Worth, Texas.

Kalia, R.K., and Schumacher, L.C.

"Electrochemical Technologies: Ontario Hydro's Perspective", Spring Meeting of the Electrochemical Society (Canadian Section), March 27, 1987, Toronto, Ontario.

see also Colman, J.E. * *et al*.

Kavassalis, T.: see Melo, O.T. *et al*.

Kawaji, M.: see Lam, T. *et al*.

Kherani, N.P., Shmayda, W., and Jalbert, R.A.

"Tritium Removal from Inert Gases Using Zr₂Fe", Twelfth Symposium on Fusion Engineering, October 1987, Monterey, California.

see also Heics, A.G. *et al* and Shmayda, W.

Kindersberger, J. *: see Wiegart, N. * *et al*.

Kirshak, D.N.: see Edwards, G.C. *et al*.

Klein, R.: see Dayal, R. *et al*.

Koehler, H.P.: see Boyd, J.M.

Krasznai, J.P., Dalziel, B.P., Krochmalnek, L.S., and Williamson, A.S.

"Ontario Hydro's Waste Characterization Program and its Application to Waste Management", Ninth Annual Department Of Energy Low Level Waste Management Conference, August 25-27, 1987, Denver, Colorado.

Krishnasamy, S.G.

"Analysis of Overhead Transmission Structures by Probabilistic Methods", Fifth International Conference on Applications of Statistics and Probability in Soil and Structural Engineering, May 25-29, 1987, Vancouver, British Columbia.

see also Cragg, C.B.H.

Krishnasamy, S.G., and Ewing, H.A.

"A Comprehensive Program for Wood Pole Evaluation in Ontario Hydro", CEA Engineering and Operating Division Meeting, March 23-27, 1987, Vancouver, British Columbia.

Krishnasamy, S.G., and Ramani, N.

"Design Wind Loads for Overhead Power Lines Accounting for Wind Direction", Seventh International Conference on Wind Engineering, July 6-10, 1987, Aachen, West Germany.

Krochmalnek, L.S.: see Krasznai, J.P. *et al*.

Kuffel, J.

"Errors Encountered in Digital Recording of High-Voltage Impulses", CAGE Club Meeting, May 11, 1987, Ottawa, Ontario.

Lam, T., Chan, A.M.C., and Kawaji, M.

"Two-Phase Flow Across a Horizontal Tube Bundle", McMaster University Symposium on Nuclear Science and Engineering, October 1987, Hamilton, Ontario.

Laratta, E.: see Edwards, G.C. *et al*.

Lau, K.C.: see Crawford, A.M. *et al*.

Lawson, W.H.S., Poon, G., and Tinkler, M.J.

"Towards P-GMAW for Temper Bead Repair of Sour Service Components", EPRI Repair Welding Seminar, March 10, 1987, Charlotte, North Carolina.

Lee, J.: see Cenanovic, M. *et al*.

Lenarduzzi, F.J.

"Heat Pump Innovations and New Applications", Water Furnace Dealer Seminar, April 3-4, 1987, London, Ontario.

"Heat Pump Technology", Toronto Hydro's Energy Management Seminar, June 4, 1987, Toronto, Ontario.

Lichtenberger, P.C.: see Warr, B.D.

Lloyd, B.A., Sharma, D.K. *, and Brede, C.K. *

"A Generator Expert Monitoring System", EPRI Conference on Expert Systems Applications in Power Plants, May 27-29, 1987, Boston, Massachusetts.

Loewen, T.

"Reactor Coolant Pumps - Theoretical and Experimental Rotor Dynamics", ROMAC (Rotating Machinery and Control) University of Virginia Annual Meeting, June 21-25, 1987, San Diego, California.

MacTavish, B.D.: see Chadha, J.A. *et al*.

Madge, R.C.

"Effect of Large Metallic Structures on AM Radio Broadcast Patterns", 1987 Colloquium of CIGRE SC36 Interference, June 8-9, 1987, Montreal, Quebec.

"AM Reradiation from Transmission Lines", 1987 Colloquium of CIGRE SC36 Interference, June 8-9, 1987, Montreal, Quebec.

Maher, J.F.B.: see Griffiths, J.S. *et al*.

Malkiewicz, T.: see Cenanovic, M. *et al*.

Mangal, R.: see Mozes, M. *et al*.

*denotes other than Ontario Hydro employee

Mannik, L., Brown, S.K., and Campbell, S.R.

"The Application of Phosphor Thermometry to Generator Rotor Temperature Monitoring", International Congress on Applications of Lasers and Electro-Optics, November 8-12, 1987, San Diego, California.

see also Balbaa, I. *et al.*

Manolescu, A.V., Chow, C.K., and Csillagi, E.G.

"Morphology of In-Reactor Corrosion Scales on Zirconium-2.5 wt% Nb Alloy", NACE Corrosion 87 Conference, March 11, 1987, San Francisco, California.

Manolescu, A.V., and Mayer, P.

"Boiler-Tube Failure Diagnosis", NACE Toronto Section Meeting, October 13, 1987, Toronto, Ontario.

Mastroianni, F.: see Moles, M.D.C. *et al.*

Mayer, P.

"Boiler Tube Failure Mechanism Recognition - An Expert System", Canadian Institute of Metallurgists / Canadian Committee for Research on the Strength and Fracture of Materials Symposium, August 23-26, 1987, Winnipeg, Manitoba.

see also Balbaa, I. *et al.*; and Manolescu, A.V.

McCluskey, D.: see Mukherjee, B.

McKinley, R.S., and Patrick, P.H.

"Use of Behavioural Stimuli to Divert Sockeye Salmon Smolts at the Seton Hydro-Electric Station, British Columbia", EPRI Conference on Fish Protection at Steam and Hydro Power Plants, October 28-30, 1987, San Francisco, California.

see also Patrick, P.H.

Melo, O.T.

"Ontario Hydro's Acid Gas Control Program", Chemical Engineering Graduate Seminar at the University of Waterloo, April 9, 1987, Waterloo, Ontario.

"Options for Controlling Acid Gas Emissions", University of Toronto Fourth Year Environmental Engineering, February 10, 1987, Toronto, Ontario.

"Environmental Research at Ontario Hydro", Annual Meeting of the CEGB/OH/TVA Working Group on Collaborative Research & Development on Long-Range Transport and Atmospheric Chemistry, August 31 - September 2, 1987, Muscle Shoals, Alabama.

Melo, O.T., and Jarv, T.

"Studies of N-Type Respirator Canisters", 1987 Conference of the International Society for Respiratory Protection, October 18-22, 1987, Toronto, Ontario.

see also Cho, H.R. *et al.*

Melo, O.T., Cho, H.R., Iribarne, J.V., Niewiadomski, M., and Kavassalis, T.

"Numerical Modelling of Transformation and Redistribution of Pollutants by Clouds", Sixth International Symposium of the Commission on Atmospheric Chemistry and Global Pollution on Global Tropospheric Chemistry, August 23-29, 1987, Peterborough, Ontario.

Micheletti, W.C.: see Patrick, P.H. *et al.*

Milian, L.: see Dayal, R. *et al.*

Moles, M.D.C., Mastroianni, F., and Sinclair, A.N.

"Ultrasonic Crack-Tip Diffraction in CANDU Reactor Pressure Tubes", Canadian Institute of Metallurgists / Canadian Committee for Research on the Strength and Fracture of Materials Symposium, August 23-26, 1987, Winnipeg, Manitoba.

Morrow, R.: see Wiegart, N. *et al.*

Mozes, M.S., Mangal, R., Thampi, R., and Tubman, D.

"Ontario Hydro's R and D on Sorbent Injection for SO₂ Control; Part 1 - Pilot Scale Studies to Improve Process Performance", EPRI Conference on the Effects of Coal Quality on Power Plants, October 1987, Atlanta, Georgia.

Mukherjee, B.

"Observations on the Effect of Post-Weld Heat Treatment on J-Resistance Curves of SA-106B Seamless Piping Welds", United States National Research Council / Japan Atomic Energy Research Institute and University of Tokyo Workshop on The Role of Failure and Fracture Mechanics in Leak Before Break Assessment, May 18-19, 1987, Tokyo, Japan.

"Darlington Leak Before Break Material Test Program J-Resistance Curves", International Seminar on Leak Before Break, May 14-15, 1987, Tokyo, Japan.

Mukherjee, B., and McCluskey, D.

"Development of a Test Method for Crack Arrest Fracture Toughness of Ferritic Materials", Canadian Institute of Metallurgists / Canadian Committee for Research on the Strength & Fracture of Materials Symposium, August 1987, Winnipeg, Manitoba.

Mukherjee, P.K., and Deans, J.J.

"Service Performance of Nuclear Containment Concrete", ACI Fall Convention, November 1987, Seattle, Washington.

Naqvi, S.J.: see Nguyen, Y.V. *et al.*

Nashid, M.S.: see Bellamy, G. *et al.*

Ng, M.: see Cenanovic, M. *et al.*

Nguyen, Y.V., Hawthorne, S.H., and Naqvi, S.J.

"An Experimental Study to Immobilize Simulated High Level Uranium Waste from Reprocessing of CANDU Fuels", International Conference on Nuclear Fuel Reprocessing and Waste Management (RECOD 87), August 23-28, 1987, Paris, France.

Niemeyer, L.: see Wiegart, N. *et al.*

Niewiadomski, M.: see Melo, O.T. *et al.*

Northrup, F.J.: see Edwards, G.C. *et al.*

Northwood, D.O.: see Warr, B.D. *et al.*

Oda, S.J., Woods, B.G., and Foster, J.

"Microwave / Infrared Drying of Extruded Ceramic Forms", Eighty-fifth Annual Convention of the Canadian Ceramic Society, February 22-25, 1987, Montreal, Quebec, and The American Ceramic Society's Eighty-Ninth Annual Meeting, April 26-30, 1987, Pittsburgh, Pennsylvania.

Ogram, G.L.

"Atmospheric Dispersion Modelling System for Ontario's Nuclear Emergency Plan", Air Quality Response to Accidental Releases of Hazardous Substances Workshop, February 4-6, 1987, Toronto, Ontario.

Patrick, P.H.

"Fish Control at Annapolis Tidal GS", July 7, 1987, Halifax, Nova Scotia.

"Responses of Juvenile White Perch to Sound", July 14, 1987, New York, New York.

"Fish Control-Sonic Systems", Water Power 87 (International Conference on Hydropower), August 19-21, 1987, Portland, Oregon.

"Effectiveness of a Hidrostral Pump in the Live Transfer of American Eels", CEA Fall Meeting of Hydraulic Power Section, September 10-11, 1987, Niagara Falls, Ontario.

see also McKinley, R.S.

Patrick, P.H., and McKinley, R.S.

"Fish Control Technologies", LTV Cleveland Steel Works, April 29, 1987, Cleveland, Ohio.

"Behavioural Systems to Guide or Divert Fish at Hydro-Electric Facilities; Phase II-Field Evaluations", CEA Meeting, August 1987.

Patrick, P.H., McKinley, R.S., and Micheletti, W.C.*

"Field Testing of Behavioural Barriers for Cooling Water Intake Structures - Test Site I - Pickering Nuclear Generating Station - 1985/86", EPRI Conference on Fish Protection at Steam and Hydro Power Plants, October 28-30, 1987, San Francisco, California.

Perlman, M.

"Residential Heat Recovery, Can We Make It Work?", American Council for an Energy Efficiency Economy (ACEEE): First National Conference on Appliance Efficiency, October 26-28, 1987, Arlington, Virginia.

"Residential Water Heating - Energy Conservation Alternatives", ASHRAE Chapter, May 11, 1987, Hamilton, Ontario.

Perovic, V.: see Fleck, R.G. *et al* and Chengji, L., *et al*.

Pinnekamp, F.*: see Wiegart, N.* *et al*.

Pon, C.J.: see Currie, I.G. *et al* also Havard, D.G.

Poon, G.: see Lawson, W.H.S. *et al*.

Porter, J.W.*: see Dick, E.P. *et al*.

Powell, P.W.*: see Dick, E.P. *et al*.

Pringle, T.G.: see Jervis, R.E.*

Purdy, G.R.: see Chengji, Li, *et al*.

Radhakrishna, H.S.

"A Study of Upgrading Methods for Transmission Tower Foundations", Geotechnical Engineering Division of the American Society of Civil Engineers Convention, April 27, 1987, Atlantic City, New Jersey.

see also Crawford, A.M. *et al*.

Radhakrishna, H.S., and Tsang, R.

"Behaviour of Laterally Loaded Drill Piers in a Soft and Sensitive Clay", Geotechnical Engineering Division of the American Society of Civil Engineers Convention, April 27, 1987, Atlantic City, New Jersey.

Ramani, N.: see Krishnasamy, S.G.

Rodgers, D.W.

"Tritium Dynamics in Aquatic and Terrestrial Organisms", Chemistry / Biology / Geology Studies Seminar at the Canada Centre for Inland Waters, March 10, 1987, Burlington, Ontario.

Ruddick, J.N.R.*: see Hawthorne, S.H.

Schumacher, L.C.: see Kalia, R.K.

Sharma, D.K.*: see Lloyd, B.A. *et al*.

Shinn, R.A.*: see Dick, E.P. *et al*.

Shmayda, W.T.

"Tritium-Material Interaction Studies at Ontario Hydro Research Division", University of McMaster Fusion Materials Seminar, February 26, 1987, Hamilton, Ontario.

see also Heics, A.G. *et al* and Kherani, N.P. *et al*.

Shmayda, W.T., and Kherani, N.P.

"Application of Hydrogen Permeation Through Bilayer Metal Membranes", Twelfth Symposium on Fusion Engineering, October 1987, Monterey, California.

Shmayda, W., Kherani, N.P., and Heics, A.G.

"Tritium Removal from Noble Gas Streams", Thirty Fourth AVS National Symposium, November 1987, Anaheim, California.

Shoukri, M.: see Abdul-Razzak, A. *et al*.

Sinclair, A.N.: see Moles, M.D.C. *et al*.

Singh, V.P.

"On-Power Containment Leakage Tests at Rolphoton Nuclear Power Development", Twenty-Fourth Annual CNA Conference, June 14-18, 1987, St. John, New Brunswick.

Soong, S.T.*: see Cho, H.R.* *et al*.

Stone, G.C., and Bernstein, B.S.*

"Toward Assessing the Remaining Life of Rotating Machine Insulation", IEEE Electrical Insulation Conference, October 1987, Chicago, Illinois.

Strack, J.T.

"A Review of R and D Activities on Industrial Heat Pumps for Food and Beverage Applications", Food and Beverage Industry Symposium, February 19-20, 1987, Montreal, Quebec.

Strickert, R.J.: see Chadha, J.A.

Sturup, V.R.: see Hooton, R.D.

Sulowski, A.C.

"Fall Protection in Transmission and Design Operations at Ontario Hydro", IEEE-ESMO 87 Construction Presentation, September 22-24, 1987, Albuquerque, New Mexico.

"Fall Protection at Ontario Hydro", National Safety Congress, October 7, 1987, Chicago, Illinois.

"Introduction to Fall Protection for Electric Utility", New York Power Authority, November 9-10, 1987, Niagara Falls, New York.

*denotes other than Ontario Hydro employee

Sulowski, A.C., and Brinkley, J.W.

"Measurement of Maximum Arrest Force in Performance Tests of Fall Protection Equipment - Proposed Frequency Response", Second International Symposium on the Performance of Protective Clothing, January 19-22, 1987, Tampa, Florida.

Sykes, J.F.*: see Chan, H.T. *et al.*

Tadros, J.: see Fleck, R.G. *et al.*

Thampi, R.: see Mozes, M. *et al.*

Thurtell, G.*: see Edwards, G.C. *et al.*

Tinkler, M.J.: see Lawson, W.H.S. *et al.*

Trass, O.*: see Gonzalez, F.

Tsang, R.: see Radhakrishna, H.S.

Tubman, D.: see Mozes, M.S. *et al.*

Urbanic, V.F.: see Warr, B.D. *et al.*

Wang, L.

"Spare Transformers in Transmission Systems - Reliability and Capital Cost Considerations", IEEE / CSEE Conference on High-Voltage Transmission Systems, October 17-22, 1987, Peoples' Republic of China.

Warr, B.D., and Lichtenberger, P.C.

"Corrosion Performance of Zr-2.5 wt% Nb Pressure Tubes in Ontario Hydro's Operating CANDU Nuclear Reactors", Twenty-Seventh Annual Conference of the CNA / Eighth Annual Conference of the CNS, June 14-18, 1987, St. John, New Brunswick.

Warr, B.D., Hardie, M.W., Urbanic, V.F., and Northwood, D.O.

"Corrosion Performance of Pressure Tubes in CANDU Reactors", Asian Pacific Corrosion Conference, November 23-27, 1987, Melbourne, Australia.

Wiegart, N.*, Niemeyer, L.*, Pinnekamp, F.*, Boeck, W.*, Kindersberger, J.*, Morrow, R.*, Zeangl, W.*, Zwicky, M.*, Gallimberti, I.*, and Boggs, S.A.

"Inhomogeneous Field Breakdown in GIS - The Prediction of Breakdown Probabilities and Voltages: Part I - Overview of a Theory for Inhomogeneous Field Breakdown in SF₆; Part II - Ion Density and Statistical Time Lag; Part III - Discharge Development in SF₆ and Computer Model of Breakdown", IEEE Winter Power Meeting, February 1987.

Williamson, A.S.

"Characterization of Low-Level Incinerable Waste and Ash", Incineration of Mixed and Low-Level Wastes Conference, April 22-24, 1987, St. Charles, Illinois.

see also Krasznai, J.P. *et al.*

Woods, B.G.: see Oda, S.J. *et al.*

Woo, C.H.: see Causey, A.R. *et al.*

Wright, S.C.

"Atmospheric Dispersion Modelling for the Bruce '86 Nuclear Exercise", Air Quality Response to Accidental Releases of Hazardous Substances Workshop, February 4-6, 1987, Toronto, Ontario.

"Environmental Modelling at Ontario Hydro Research Division", Summer Conference of the Society for Computer Simulation, July 26-30, 1987, Montreal, Quebec.

see also Edwards, G.C. *et al.*

Young, D.J.

"The Electric Heat Pump: Something for Everybody", Heat Pump Conference & Exhibition, March 11, 1987, Toronto, Ontario.

Zeangl, W.*: see Wiegart, N.* *et al.*

Zeya, M., Gonzalez, L.A., and Braun, J.M.

"Gas Permeation Characteristics of Protective Suits and Safety Materials used in CANDU Plant Service", International Conference on CANDU Maintenance, November 22-24, 1987, Toronto, Ontario.

Zwicky, M.*: see Wiegart, N.* *et al.*

*denotes other than Ontario Hydro employee

Anders, G.J.

"Reliability Evaluation of Systems with After-Fault Switching", IEEE Transactions on Power Systems, August 1987.

"Advanced Tools and Techniques for Power Cable Thermal Analysis", Proceedings of the 1987 CIRED Conference, May 1987.

Anders, G.J., Ganton, R.W., Bedard, N. *, and Chaaban, M. *
"New Approach to Ampacity Evaluation of Cables in Ducts Using Finite Element Technique", IEEE Transactions on Power Delivery, July 1987.

Anders, G.J., and Radhakrishna, H.S.

"Power Cable Thermal Analysis with Consideration of Heat and Moisture Transfer in the Soil", IEEE Transactions on Power Delivery, July 1987.

see also El-Kady, M.A. *et al.*

Anderson, H.L.: see Loewen, T. *et al.*

Arron, G.P., and Camacho, F.

"Reduction of the Number of Internodes and Internode Length in Sprouts Formed in Silver Maple Injected with Flurprimidol, Paclobutrazol or MBR 18337", Proceedings of the Fourteenth Annual Meeting of the Plant Growth Regulator Society of America, August 1987, pp 288-294.

Bacvarov, D.C. *: see Gupta, B.K. *et al.*

Balbaa, I.S., Hardy, P.A., San-Martin, A., Coulter, P.G., and Manchester, F.D.

"The Effect of Lattice Distortions on the X-ray Measurement of Lattice Parameter for PdH_x-1: Empirical Relations", Journal of Physics:F, Vol 17, No 10, 1987, p 2041.

Ballyk, J.D. *, Shoukri, M., and Chan, A.M.C.

"Experimental Investigation of Steam-Water Annular Flow in Piping Junctions", Transactions of ASME Winter Annual Meeting, Paper 87-WA/NE-8.

Baron, J.A.

"Computers in Nondestructive Evaluation", CSNDT Journal, November / December 1987, p 34.

"Privatization of the NDT Certification Program", CSNDT Journal, November / December 1987, p 28.

Baron, J.A., and Humphries, W.J.

"Certification of NDT Personnel in Canada", Conference Proceedings of the Fifth Pan-Pacific Conference on Nondestructive Testing, p. 147; and Quarterly Journal of Canadian General Standards Board, Autumn 1987, Vol 15, No 4, p 4.

Bhat, P.D.: see Vecchio, F.J. *et al.*

Bickley, J.: see Mukherjee, P.K.

Boag, J.M.: see Flaman, M.T. *et al.*

Boggs, S.A., Wiegart, N. *, Mcppelink, J. *, and Diederich, J. *

"Fundamental Knowledge and Testing of GIS - Present State and Future Needs", Gaseous Dielectrics V, May 1987.

Boggs, S.A., Pecena, D.D. *, Rizzetto, S., and Stone, G.C.

"Limits to Partial Discharge Detection - Effects of Sample and Defect Geometry", Proceedings of the CIGRE Symposium on New and Improved Materials for Electrotechnology, May 1987, Paper # 700-04.

see also Fujimoto, N. *et al*; Rizzetto, S.; Stone, G.C. *et al*; and Wiegart, N. * *et al.*

Bosmans, R.F.: see Boyd, J.M.

Bourne, O.L.: see Morrison, H.D. *et al.*

Boyd, J.M., and Bosmans, R.F.

"Monitoring for Predictive Maintenance in Hydropower Plants Experience and Conclusions", Proceedings of the Fourteenth Inter-Ram Conference for the Electric Power Industry, May 1987, pp 224-231.

Braun, J.M., Gonzalez, L.A., and Chu F.Y.

"A Model of Moisture Ingress and Distribution in Gas-Insulated Switchgear", Proceedings of the CIGRE Symposium on New and Improved Materials for Electrotechnology, May 1987, paper #400-04.

see also Chu, F.Y. *et al* and Stone, G.C. *et al.*

Brown, S.K.: see Mannik, L., *et al.*

Byrne, T.P.: see Leger, M.

Camacho, F., and Punhani, A.L.

"Development of a National Sampling Plan for Revenue Meters for Canadian Utilities", CEA Engineering & Operating Division Transactions, March 1987, Vol 26.

see also Arron, G.P.

Campbell, S.R.: see Gupta, B.K. *et al* and Mannik, L. *et al.*

Carmichael, T.J.: see Sturup, V.R. *et al.*

Carpenter, D.: see Mukherjee, B.

Causey, A.R.: see Parker, J.D. *et al.*

Cenanovic, M., and Maureira, H.

"The AC Device for Repositioning of Garter Springs in CANDU Reactors", Nuclear Journal of Canada, Vol 1, No 4, December 1987.

Chan, A.M.C., and Shoukri, M.

"Boiling Characteristics of Small Multitube Bundles", ASME Journal of Heat Transfer, Vol 109, pp 753-760.

see also Ballyk, J.D. * *et al* and Shoukri M.

Cherney, E.A., and Hooton, R.D.

"Cement Growth Failure Mechanism in Porcelain Suspension Insulators", IEEE Transactions on Power Delivery, Vol PWRD-2, No 1, January 1987, pp 249-255.

Christie, A.E.: see Patrick, P.H. *et al.*

Chu, F.Y.

"Gas Analysis as a Diagnostic Tool for Gas-Insulated Equipment", Gaseous Dielectrics V, p 219.

Chu, F.Y., Braun, J.M., and McIntyre, N.S.

"Applications of Electron Spectroscopy in GIS Spacer Surface Analysis", Gaseous Dielectrics V, p 567.

Chu, F.Y., and Fujimoto, N.

"Diagnostic Techniques for Gas-Insulated Substations", CEA Engineering and Operating Division Transactions, March 1987, Vol 26.

see also Braun, J.M. *et al.*

Coulter, P.G.: see Balbaa, I.S. *et al.*

Cress, S.L., and Krishnasamy, S.
"Probabilistic Techniques Applied to Selected Distribution System Problems", Proceedings of the Fourteenth Inter-Ram Conference, May 1987, p 638.

Cuthbert, D.F.
"The Bivalent Heat Pump - A Technology and Market Overview", Proceedings of the Canadian Heat Pump Symposium, Vol 2, Chap. 17, June 1987, pp 17.1-17.7.

Daechsel, P.: see Kurtz, M. *et al.*

El-Kady, M.A., Anders, G.J., Motlis, J., and Horrocks, D.J.
"Modified Values for Geometric Factor of External Thermal Resistance of Cables in Duct Banks", IEEE Transactions on Power Delivery, October 1987.

Emery, J.J.: see Hooton, R.D.

Endrenyi, J.
"Power System Reliability Analysis - Application Guide", CIGRE Working Group 38.03, 1987. (Co-author & Co-editor).

Erven, C.C.: see Kirkby, P. *et al.*

Fitzgerald, J.P.*: see Gupta, B.K. *et al.*

Flaman, M.T., Mills, B.E., and Boag, J.M.
"Analysis of Stress Variation with Depth Measurement Procedures for the Center Hole Method of Residual Stress Measurement", Experimental Techniques, June 1987, pp 35-37.

Flaman, M.T., Herring, J.A., and Shah, N.N.
"A Comparison of Calibration Procedures for Weldable Strain Gauges to Obtain Apparent Strain Data to 400°C", Experimental Techniques, August 1987, pp 31-33.

Fleck, R.G.: see Parker, J.D. *et al.*

Fujimoto, N.
"Conduction Currents in Gas-Insulated Switchgear for Low-Level DC Stress", Gaseous Dielectrics V, May 1987, pp 513-519.

"Practical Considerations in Protecting Gas-Insulated Substation to Cable Interfaces", CEA Engineering and Operating Division Transactions, Vol 26, March 1987.

Fujimoto, N., Boggs, S.A., and Stone, G.C.
"Mechanisms and Analysis of Short Risetime GIS Transients", Proceedings of the CIGRE Symposium on New and Improved Materials for Electrotechnology, May 1987, paper #1010-03.

see also Chu, F.Y.

Ganton, R.W.: see Anders, G.J. *et al.*

Gnoyke, R.E.: see Mader, D.L.

Golomb, A., and Nott, B.
"Ontario Hydro's R&D on Sorbent Injection for SO₂ Control: Part 2 - Waste Characterization", Proceedings of the Effects of Coal Quality on Power Plants Conference, October 1987.

Gonzalez, F., and Spekkens, P.
"Concentration Processes Under Tubesheet Sludge Piles in Nuclear Steam Generators", Nuclear Journal of Canada, Vol 1, No 2, June 1987, p 129.

Gonzalez, F., and Trass, O.
"A Shock Tube Study of the Pyrolysis of Nitric and Nitrous Oxide", Proceedings of the Sixteenth Shock Tube and Wave Symposium, July 1987.

Gonzalez, L.A.: see Braun, J.M. *et al.*

Gorur, R.S.*, Cherney, E.A., and Hackam, R.*
"Performance of Polymeric Insulating Materials in Salt-Fog", IEEE Transactions - PWRD, April 1987, pp 486-491.

Gupta, B.K., Sharma, D.K.*, and Bacvarov, D.C.*
"Measured Winding Impedances of a Large AC Motor", IEEE Transactions on Energy Conversion, EC-2, March 1987, pp 139-151.

Gupta, B.K., Lloyd, B.A., Stone, G.C., Campbell, S.R., Sharma, D.K.*, and Nilsson, N.E.*
"Turn Insulation Capability of Large AC Motors: Part 1 - Surge Monitoring", IEEE Transactions on Energy Conservation, EC-2, December 1987, pp 658-665.

Gupta, B.K., Lloyd, B.A., Sharma, D.K.*, and Fitzgerald, J.P.*
"Turn Insulation Capability of Large AC Motors: Part 2 - Impulse Strength", IEEE Transactions on Energy Conservation, EC-2, December 1987, pp 666-673.

Gupta, B.K., Lloyd, B.A., Stone, G.C., Sharma, D.K.*, Nilsson, N.E.*, and Fitzgerald, J.P.*
"Turn Insulation Capability of Large AC Motors: Part 3 - Insulation Coordination", Institute of Electrical and Electronics Engineers Transactions on Energy Conservation, EC-2, December 1987, pp 674-679.

see also Kemp, I. *et al.*; and Kurtz, M. *et al.*

Hackett, P.A.: see Morrison, H.D. *et al.*

Hardy, P.A.: see Balbaa, I.S. *et al.*

Havard, D.G., and Pohlman, J.C.*
"Progress in Field Research on Control of Galloping of Iced Conductors", Proceedings of the Second International Workshop on Atmospheric Icing of Structures, pp 195-203.

Havard, D.G., Pon, C., and Watt, G.S.
"Clearances for Galloping on Overhead Lines", Proceedings of the First International Symposium on Probabilistic Methods Applied to Electric Power Systems, pp 503-512.

Herring, J.A.: see Flaman, M.T. *et al.*

Hester, R.A.: see Patrick, P.H. *et al.*

Holsapple, J.G.: see Patrick, P.H. *et al.*

Hooton, R.D.
"Some Aspects of Durability with Condensed Silica Fume in Pastes, Mortars and Concretes", Proceedings of the CANMET International Workshop on the use of Silica Fume in Concrete, May 1987, Paper #19, p 30.

*denotes other than Ontario Hydro employee

"The Reactivity and Hydration Products of Blast-Furnace Slags", Supplementary Cementing Materials, CANMET, October 1987, pp 247-288.

"Effects of Containers on ASTM C 441 Pyrex Mortar Bar Expansions", Proceedings of the Seventh International Conference on Alkali-Aggregate Reaction, August 1987, pp 351-357.

"Effects of Fly Ash and Bottom Ash Fills on Embedded Concrete", Proceedings of the Eighth International Coal Ash Utilization Symposium, EPRI C5-5362, Vol 2, October 1987, pp 48A1-48A16.

see also Sturupp, V.R. *et al* and Cherney, E.A.

Hooton, R.D., and Emery, J.J.

"Sulphate Resistance of a Canadian Slag Cement", Proceedings of the CANMET International Workshop on Silica Fume, October 1987, p 24.

Horrocks, D.J.: see El-Kady, M.A. *et al*.

Humphries, W.J.: see Baron, J.A.

Hutchins, D.A.: see Kramer, S.M. *et al*.

Jakubick, A.T., Gillham, R.W.*, Kahl, I.*, and Robin, M.*

"Attenuation of Pu, Am, Cs and Sr Mobility in Concrete", Proceedings of the Materials Research Society Symposium, Vol 84, pp 355-368.

Kemp, I., Gupta, B.K., and Stone, G.C.

"Calibration Difficulties Associated with Partial Discharge Detectors in Rotating Machine Applications", Proceedings of the IEEE Electrical Insulation Conference.

Keyes, C.E.

"Failure Analysis of a 100-kW Liquid-to-Liquid R-114 Heat Pump", Proceedings of the Canadian Heat Pump Symposium, Vol 2, Chapter 16, June 1987.

King, P.J.

"Pitting Corrosion Behaviour of Alloy 800 in Chloride", Corrosion-NACE, Vol 43, No 1, January 1987, pp 37-45.

Kirkby, P.

"Fostering Physics", Crucible, Vol 18, March-April 1987, p 48.

Kirkby, P., Hartley, I.D.*, and Joos, B.*

"The Canadian Association of Physicists: Looking to the Future", Physics in Canada, Vol 43, No 1, January 1987, pp 39-43.

Kirkby, P., Erven, C.C., and Nigol, O.

"Long-Term Stability and Energy Discharge Capacity of Metal Oxide Valve Elements", IEEE Transactions on Power Delivery, July 1987, Paper # 87 SM 531-7.

Kramer, S.M., McBride, S.L., Mair, H.D., and Hutchins, D.A.

"Characteristics of Wide-Band Planar Ultrasonic Transducers Using Plane and Edge Wave", IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control.

Kramer, S.M., Hutchins, D.A., and Mair, H.D.

"Use of Plane & Edge Wave Components to Characterize PVDF Transducers", Proceedings of Ultrasonics International Conference 87, pp 838-843.

Krishnasamy, S.G.: see Cress, S.L.

Kuffel, J.: see McComb, T.R.* *et al*.

Kurtz, M.

"Tracking", IEEE Electrical Insulation Magazine, Vol 3, No 3, May 1987, pp 12-14.

Kurtz, M., Stone, G.C., Daechsel, P., and Gupta, B.K.

"Fault Anticipator for Substation Equipment", IEEE Transactions on Power Delivery, PWRD-2 July 1987, pp 722-724.

see also Stone, G.C. *et al*; and Ward, B.E.* *et al*.

Lee, W.K.: see Westwood, H.J.

Leger, M., and Byrne, T.P.

"Hydride Blister Growth in Zr-2.5 wt% Nb Pressure Tube Material", Proceedings of Fuel Channel Technology Seminar, February 1987, CRNL 2950 Ontario Hydro Design & Development-Generation 85431.

see also Parker, J.D. *et al*.

Lepik, O.E.: see Wallace, A.C. *et al*.

Lewak, R., Cielo, P.*, Maldague, X.*, and Deom, A.A.*

"Thermographic Nondestructive Evaluation of Industrial Materials and Structures", Materials Evaluation, April 1987, Vol 45, No 6, pp 452-460.

Lloyd, B.A.: see Gupta, B.K. *et al*.

Loewen, T., Perricone, F., and Anderson, H.L.

"Plant Equipment Dynamics - Specifications, Commissioning and Monitoring for Improved Reliability", Proceedings of the Fourteenth Inter-RAM Conference for the Electric Power Industry, May 1987, pp 489-496.

Mader, D.L.

"Holographic NDT on Pipes: Predicted Fringe Patterns and Experimental Results", SPIE - Optical Testing and Metrology, Vol 661, 1986, pp 26-35.

Mader, D.L., and Gnoyke, R.E.

"Vacuum Speckle Interferometry for Long-Term Monitoring of In-Plane Strains at Defect Sites in Nuclear Pressure Tubes", SPIE - Industrial Laser Interferometry (1987), Vol 746, pp 113-120.

Mair, H.D.: see Kramer, S.M. *et al*.

Manchester, F.D.: see Balbaa, I.S. *et al*.

Mannik, L., Brown, S.K., and Campbell, S.R.

"Phosphor-Based Thermometry of Rotating Surfaces", Applied Optics, Vol 26, p. 4014.

Marttila, R.J.

"Effect of Transmission Line Loading on the Performance of Polyphase Distance Relay Elements", IEEE Engineering Society Transactions, July 1987, Paper #87 SM 631-5.

"A New Generator Stator Ground Relay for 100 Per Cent Coverage of the Stator Winding", Proceedings of the Conference of Pennsylvania Electric Association Engineering Section Relay Committee.

"A General Method for the Analysis of Distance Relay Elements", Proceedings of the Western Protective Relay Conference.

Maureira, H.: see Cenancovic, M.

McBride, S.L.: see Kramer, S.M. *et al*.

*denotes other than Ontario Hydro employee

- McComb, T.R.*, Kuffel, J., Malewski, R.*, and Schon, K.*
 "Qualifying an Impulse Digitizer for Measurements in High Voltage Impulse Tests", IEEE Transactions on Power Delivery, July 1987.
- McIntyre, N.S.: see Chu, F.Y. *et al.*
- McKinley, R.S., and Patrick, P.H.
 "Use of Behavioural Stimuli to Divert Sockeye Salmon Smolts at the Seton Hydro-Electric Station, British Columbia", Proceedings of the EPRI Conference on Fish Protection at Steam and Hydro Power Plants, October 1987.
- McKinley, R.S., Patrick, P.H., and Mussali, Y.
 "Influence of Three Sonic Devices on Fish Behaviour", Special Proceedings of American Society of Civil Engineering Conference on Water Power '87, August 1987.
- see also Patrick, P.H. *et al.*
- Micheletti, W.C.: see Patrick, P.H. *et al.*
- Mills, B.E.: see Flaman, M.T. *et al.* and Perlman, M.
- Morrison, H.D., Hackett, P.A., Rayner, D.M. and Bourne, O.L.
 "Laser Separation of Zirconium Isotopes", Conference on Lasers and Electro-Optics Technical Digest, Series 1987, Vol 14, p 34.
- Motlis, J.: see El-Kady, M.A. *et al.*
- Mukherjee, B., and Carpenter, D.
 "Fracture Resistance of SA-106B Seamless Piping and Welds", Proceedings of Ninth International Conference on Structural Mechanics in Reactor Technology, Vol A, pp 155-162.
- Mukherjee, P.K., and Bickley, J.
 "Performance of Glass as Concrete Aggregate", Proceedings of the NRC Symposium on Concrete-Aggregate Alkali Reaction, pp 36-43.
- "Effective Containers on ASTM C441 Pyrex Mortar Bar Expansions", Proceedings of the NRC Symposium on Concrete-Aggregate Alkali Reaction, pp 351-357.
- see also Sturup, V.R. *et al.*
- Mussali, Y.: see McKinley, R.S. *et al.*
- Nigol, O.: see Kirkby, P. *et al.*
- Nott, B.: see Golomb, A.
- Oda, S.J., Woods, B.G., and Foster, J.*
 "Microwave / Infrared Drying of Extruded Ceramic Forms", Journal of the Canadian Ceramic Society, Vol 56, 1987, pp 70-73.
- Parker, J.D., Causey, A.R., and Fleck, R.G.
 "Creep and Growth Tests of Pressure Tubes", Proceedings of Fuel Channel Technology Seminar, February 1987, CRNL 2950, Ontario Hydro Design & Development-Generation 85431.
- Parker, J.D., Perovic, V., Leger, M., and Fleck, R.G.
 "Microstructural Effects on the Irradiation Growth of Zr-2.5 wt% Nb", Zirconium in the Nuclear Industry, STP 939, September 1987.
- Patrick, P.H., and McKinley, R.S.
 "Laboratory and Field Experiments Involving a Hidrostral Pump in the Live Transfer of American Eels", Proceedings of the CEA Hydraulic Power Section, September 1987.
- "Field Evaluation of a Hidrostral Pump in the Live Transfer of American Eels at a Hydro-Electric Facility", North American Journal of Fisheries Management, Vol 7, No 2, October 20, 1987, pp 303-305.
- Patrick, P.H., Hester, R.A., Wiancko, P., and Christie, A.E.
 "Fish Impingement at Ontario Hydro's Generating Stations", Proceedings of the Conference on Mechanisms of Compensatory Response of Fish Populations, June 1987.
- Patrick, P.H., McKinley, R.S., and Micheletti, W.C.
 "Field Testing of Behavioural Barriers for Cooling Water Intake Structures; Test Site 1 - Pickering Nuclear Generating Station", Proceedings of the EPRI Conference on Fish Protection at Steam and Hydro Power Plants, October 1987.
- Patrick, P.H., McKinley, R.S., Christie, A.E., and Holsapple, J.G.
 "Fish Protection: Sonic Deterrents", Proceedings of the EPRI Conference on Fish Protection at Steam and Hydro Power Plants, October 1987.
- see also McKinley, R.S. *et al.*
- Perlman, M., and Mills, B.E.
 "Development of Residential Hot Water Use Patterns (Research Note)", ASHRAE Journal, Vol 29, No 4, April 1987, pp 43-44.
- "Residential Hot Water Use Patterns (Relevant Results of ASHRAE Research Project RP 430)", ASHRAE Handbook, Systems & Applications, Chapter 54, June 1987, pp 54.10 - 54.13.
- Perovic, V.: see Parker, J.D. *et al.*
- Perricone, F.: see Loewen, T. *et al.*
- Pon, C.J.: see Havard, D.G. *et al.*
- Pringle, T.G., and Jervis, R.E.*
 "The Redistribution of Trace and Minor Elements During Coal Hydroliquefaction", Canadian Journal of Chemical Engineering, Vol 65, No 3, June 1987, pp 494-499.
- "Multi-Element Correlations for Airborne Particulate Attribution", Journal of Radioanalytical and Nuclear Chemical Articles, Vol 110, No 2, July 1987, pp 321-332.
- "A Particle-Size Specific Elemental Mass Balance for the Apportionment of Ambient Aerosol", Journal of Radioanalytical and Nuclear Chemical Articles, Vol 112, No 1, September 1987, pp 243-258.
- Punhani, A.L.: see Camacho, F.
- Radhakrishna, H.S.: see Anders, G.J.
- Rayner, D.M.: see Morrison, H.D. *et al.*
- Rizzetto, S., Stone, G.C., and Boggs, S.A.
 "The Influence of x-Rays on Partial Discharge in Voids", CEIDP, October 1987.
- see also Boggs, S.A. *et al.*
- San-Martin, A.: see Balbaa, I.S. *et al.*
- Sato, J.A.: see Vecchio, F.J. *et al.*
- Shah, N.N.: see Flaman, M.T. *et al.*

Shek, G.K.: see Wallace, A.C. *et al.*

Shoukri, M., and Chan, A.M.C.

"On the Thermal Analysis of Pressure Tube / Calandria Tube Contact in CANDU Reactors", Vol 104, pp 197-206.

see also Chan, A.M.C. and Ballyk, J.D. * *et al.*

Sim, S.H.

"Reliability of Standby Equipment with Periodic Testing", IEEE Transactions on Reliability, Vol R-36, No 1, April 1987, pp 117-123.

Spekkens, P.: see Gonzalez, F.

Stone, G.C., Boggs, S.A., Braun, J.M., and Kurtz, M.

"Reliability of Epoxy Components in High Voltage Switchgear", Proceedings of the CIGRE Symposium on New and Improved Materials for Electrotechnology, May 1987.

see also Boggs, S.A. *et al.*; Fujimoto, N. *et al.*; Gupta, B.K. *et al.*; Rizzetto, S.; Ward, B.E. * *et al.*; Kemp, I. *et al.*; and Kurtz, M. *et al.*

Strack, J.T.

"A Review of R and D Activities on Industrial Heat Pumps for Food and Beverage Applications", Proceedings of the Canadian Committee on Electrotechnologies Food Processing Seminar, February 1987.

"A Review of R and D Activities on Industrial Heat Pumps by a Canadian Electric Utility", Proceedings of the Third International Symposium on the Large Scale Applications of Heat Pumps, Paper H2, March 1987, pp 177-183.

"Heat Pumps in Drying Applications in Canada", Proceedings of the Fourteenth Energy Technology Conference and Exposition, April 1987, pp 707-722.

Sturupp, V.R., Hooton, R.D., Mukherjee, P.K., and Carmichael, T.J.

"Evaluation and Prediction of Concrete Durability - Ontario Hydro's Experience", Proceedings of the Katharine and Bryant Mather International Conference on Concrete Durability, ACI SP 100, Vol 2, April 1987, pp 1121-1154.

Sulowski, A.C.

"Fall Protection Systems: At the End of Your Rope", Occupational Health and Safety Canada, Vol 3, No 6, November / December 1987.

Thomas, G.F.

"Evolution Operator for a Multi-Level System in a Continuous-Wave Laser Field", Physical Review A, Vol 35, No 10, May 1987, pp 4238-4246.

"Pulse Train Single-Photon included Optical Ramsey Fringes", Physical Review A, Vol 35, No 12, June 1987, pp 5060-5063.

"Laser-Pulse Induced n-Photon Absorption in an Atom or Molecule Aligned by a Static Electric Field", Journal of Chemical Physics, Vol 86, No 1, January 1987, pp 71-76.

"Residue Decompositions of the Propagator for Time-Independent Hamiltonian Operators", Physical Review A, Vol 36, No 2, July 15, 1987, pp 989-991.

"Diffusional Release of a Single Component Material From a Finite Cylindrical Waste Form", Annals of Nuclear Energy, Vol 14, No 6, pp 283-294.

Thomas, G.F., and Sora, K. *

"The Concentration-Time Profile in a Recirculating Electrochemical Reactor", Electrochimica Acta, Vol 32, No 4, March 1987, pp 673-675.

Trass, O.: see Gonzalez, F.

Vecchio, F.J., Sato, J.A., and Bhat, P.D.

"Thermal Creep in Reinforced Concrete Structures", Transactions of the Ninth International Conference on Structural Mechanics in Reactor Technology, August 1987.

Wallace, A.C.

"Numerical Analysis of Zirconium Hydride Blisters in CANDU Reactor Pressure Tubes", Transactions of the Ninth International Conference on Structural Mechanics in Reactor Technology, August 1987.

Wallace, A.C., Lepik, O.E., and Shek, G.K.

"Effects of Hydride Morphology on Zr-2.5 Nb Fracture Toughness", American Society for Testing and Materials Special Technical Publication.

Ward, B.E. *, Stone, G.C., and Kurtz, M.

"The Voltage Endurance Test - A Quality Control Test for High Voltage Stator Insulation", IEEE Electrical Insulation Magazine, September 1987, pp 12-17.

Watt, G.S.: see Havard, D.G. *et al.*

Westwood, H.J., and Lee, W.K.

"Corrosion Fatigue Cracking in Fossil-Fueled Boilers", Journal of Materials Engineering, Vol. 9, No. 2, 1987, p. 163.

Wiancko, P.: see Patrick, P.H. *et al.*

Woods, B.G.

"Applications of Microwave and Radio-Frequency Technologies in the Food Industry", Proceedings of the Canadian Frozen Food Association's Technical Conference, April 1987.

see also Oda, S.J. *et al.*

Wiegart, N. *, Niemeyer, L. *, Pinnekamp, F. *, Boeck, W. *, Kindersberger, J. *, Morrow, R. *, Zeangl, W. *, Zwicky, M. *, Gallimberti, I. *, and Boggs, S.A.

"Inhomogeneous Field Breakdown in GIS - The Prediction of Breakdown Probabilities and Voltages: Part 1 - Overview of a Theory for Inhomogeneous Field Breakdown in SF₆; Part 2 - Ion Density and Statistical Time Lag; Part 3 - Discharge Development in SF₆ and Computer Model of Breakdown", IEEE Winter Power Meeting, February 1987.

* denotes other than Ontario Hydro employee

SEVENTY~FIVE YEARS OF RESEARCH AT ONTARIO HYDRO

GEN. H.D.G. CRERAR
Chief Testing Engineer
1912-1914



W.P. DOBSON
Director of Research
1914-1953



G.B. TEBO
Director of Research
1953-1957



H.C. ROSS
Director of Research
1957-1967



DIRECTORS OF ONTARIO HYDRO'S RESEARCH AND DEVELOPMENT ACTIVITIES 1912-1987



J.H. WAGHORNE
Director of Research
1967-1976



F.J. SIMPSON
Director of Research
1976-1981



F.J. KEE
Director of Research
1981-1986



D. MILLS
Director of Research
1986-



FOREWORD

From a small beginning seventy-five years ago, the Research Division has grown to become a vital part of Ontario Hydro, continually striving towards the goal of better electrical service. We are proud of the contribution made by the Division to the efficient operation of Ontario Hydro and to the electrical and allied industries generally.

To mark the occasion of our 75th anniversary, this booklet has been prepared to provide readers with some insight into the nature and scope of the Division's current responsibilities and activities, a look at significant events and achievements of the past, and a glimpse of the future.

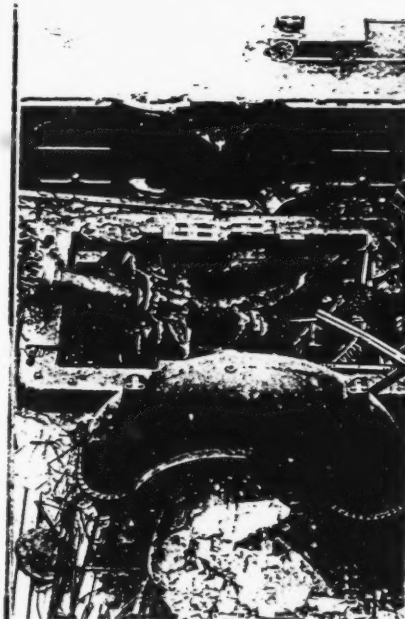
Should a reading of this booklet bring to mind some questions related to the work, inquiries for further details on any project will be welcomed, and will be answered as adequately as available information permits.

D. (Don) Mills
Director of Research

THE RESEARCH DIVISION

A pioneer in electric utility research in North America, the Research Division of Ontario Hydro has, from a modest beginning in 1912, grown to a laboratory with over 650 employees, and attained a leading position in a number of technical fields. Our objective has been to ensure that the most advanced and preferred engineering practices, consistent with sound economy, are applied throughout the power system, and that technical improvements are continually made.

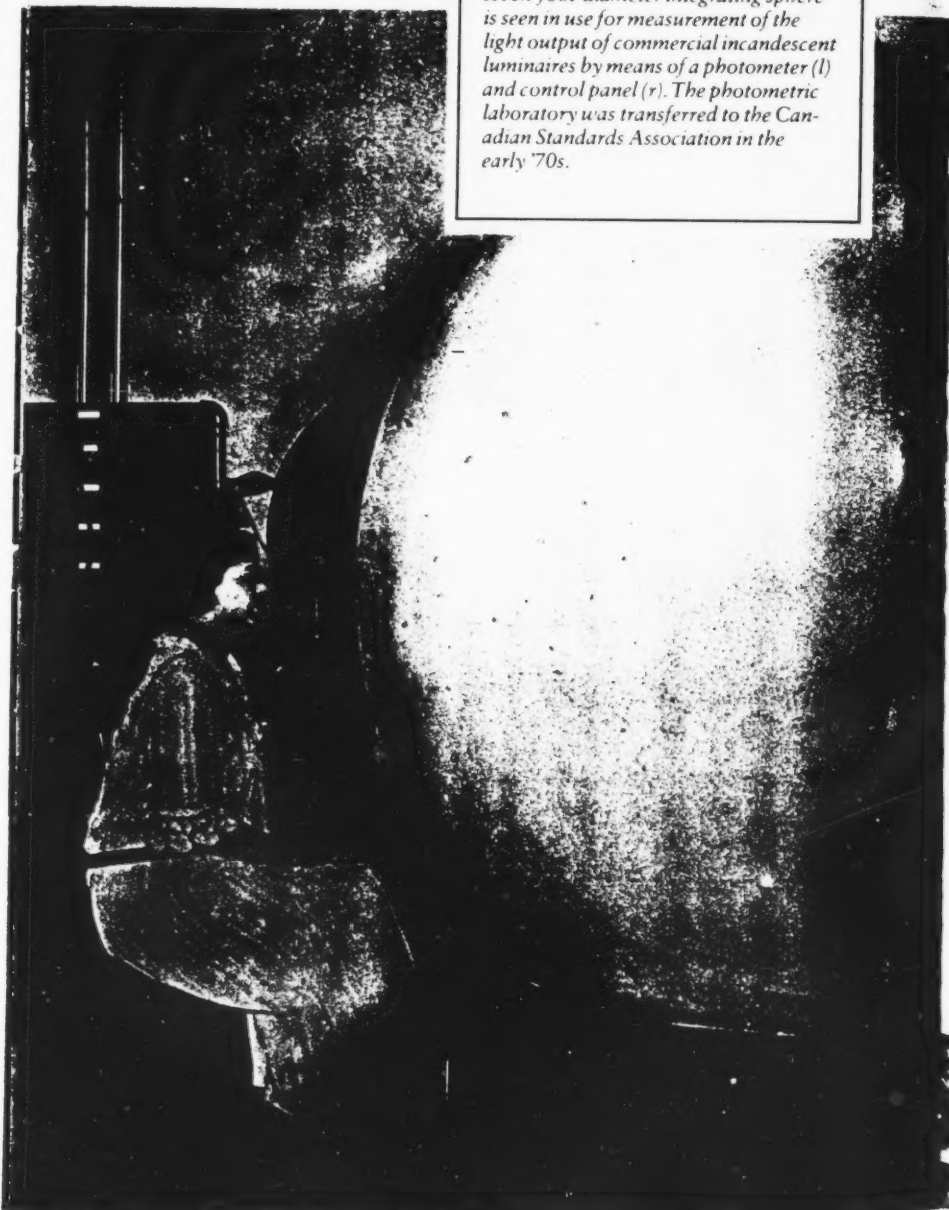
Ontario Hydro, then known as the Hydro-Electric Power Commission of Ontario, was established by an Act of the Ontario Legislature in 1906 to generate and transmit electric power to municipalities in the province at cost. Adam Beck was appointed chairman



(top right) In this scene from the '20s, hydraulic test engineers are measuring hydraulic-turbine efficiencies at Healey Fall Generating Station using, for the first time in Canada, the Gibson method.

(top left) In 1922, metallurgists and chemical engineers of the Research Division were called upon to assist in the investigation of the cause of a catastrophic metal fatigue failure of a generating unit at the Ontario Power Company's hydro-electric powerplant in Niagara Falls.

(bottom) By 1920, the photometric section of the testing and research laboratories had become well established and was being widely used by manufacturers and large purchasers for tests of the performance of luminaires and other lighting products, and by Ontario Hydro for the establishment of adequate specifications. Here, a seven-foot-diameter integrating sphere is seen in use for measurement of the light output of commercial incandescent luminaires by means of a photometer (l) and control panel (r). The photometric laboratory was transferred to the Canadian Standards Association in the early '70s.





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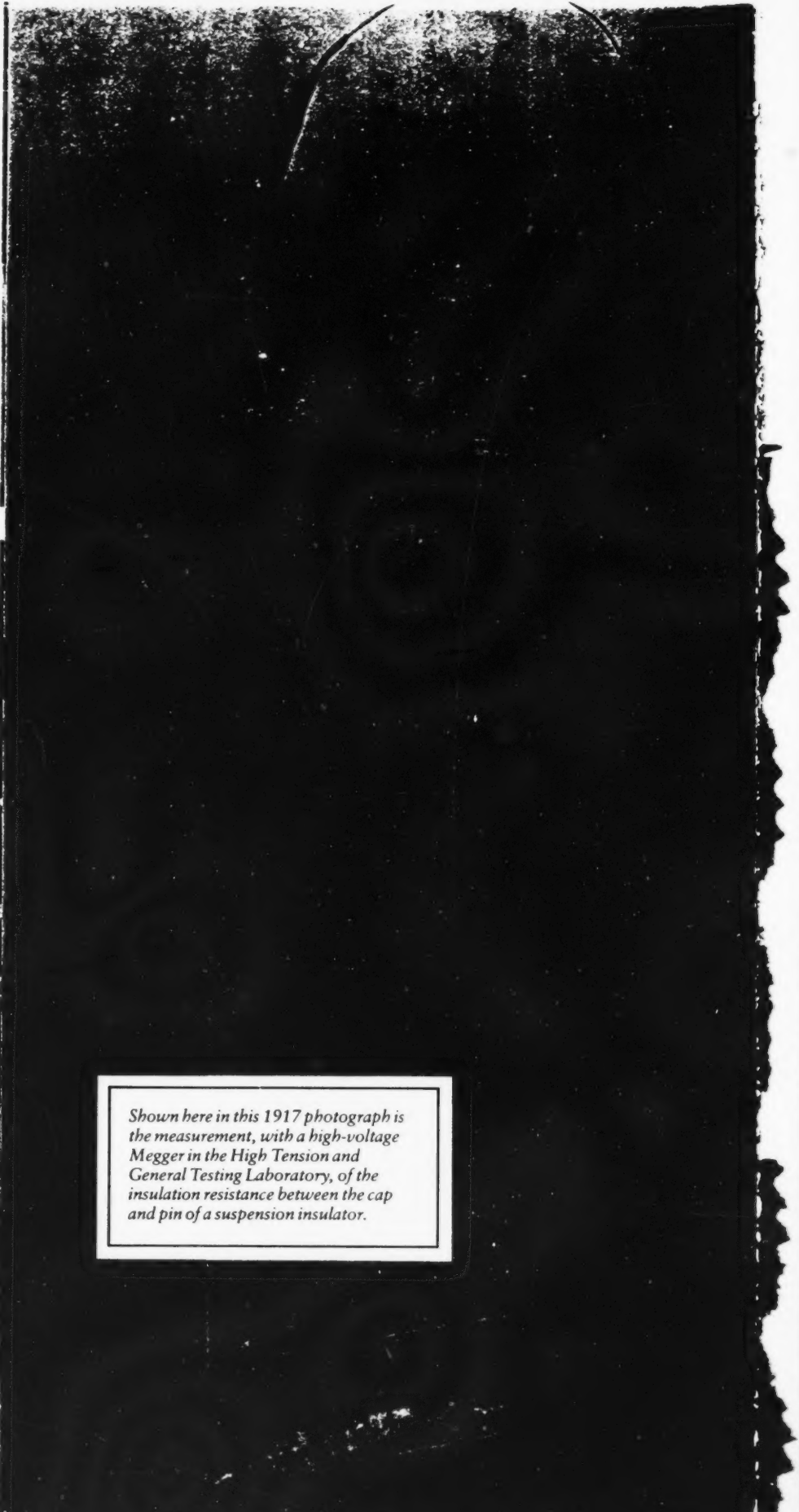
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Director of Research

THE RESEARCH DIVISION

A pioneer in electric utility research in North America, the Research Division of Ontario Hydro has, from a modest beginning in 1912, grown to a laboratory with over 650 employees, and attained a leading position in a number of technical fields. Our objective has been to ensure that the most advanced and preferred engineering practices, consistent with sound economy, are applied throughout the power system, and that technical improvements are continually made.

Ontario Hydro, then known as the Hydro-Electric Power Commission of Ontario, was established by an Act of the Ontario Legislature in 1906 to generate and transmit electric power to municipalities in the province at cost. Adam Beck was appointed chairman



Shown here in this 1917 photograph is the measurement, with a high-voltage Megger in the High Tension and General Testing Laboratory, of the insulation resistance between the cap and pin of a suspension insulator.



FOREWORD

From a small beginning seventy-five years ago, the Research Division has grown to become a vital part of Ontario Hydro, continually striving towards the goal of better electrical service. We are proud of the contribution made by the Division to the efficient operation of Ontario Hydro and to the electrical and allied industries generally.

To mark the occasion of our 75th anniversary, this booklet has been prepared to provide readers with some insight into the nature and scope of the Division's current responsibilities and activities, a look at significant events and achievements of the past, and a glimpse of the future.

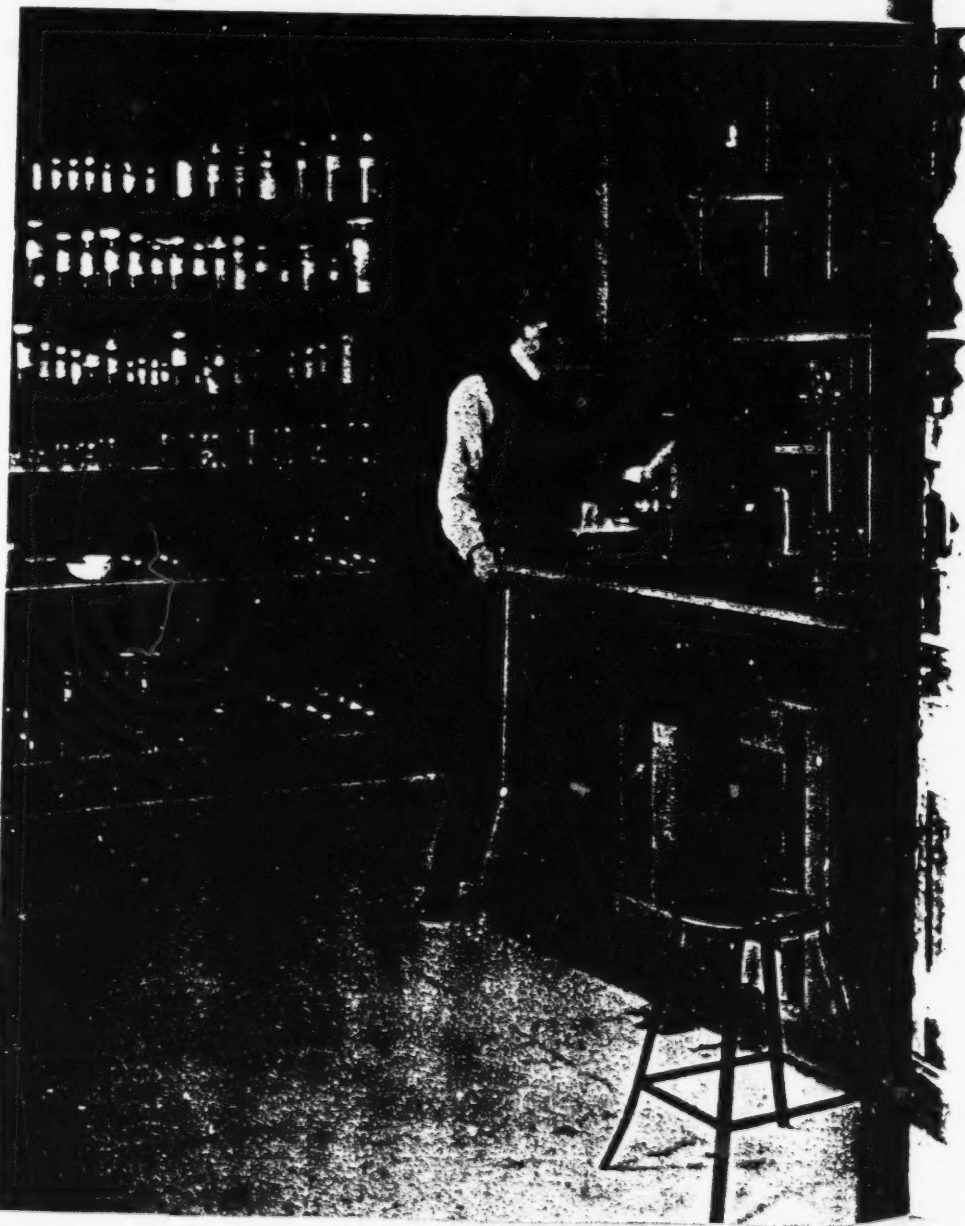
Should a reading of this booklet bring to mind some questions related to the work, inquiries for further details on any project will be welcomed, and will be answered as adequately as available information permits.

D. (Don) Mills
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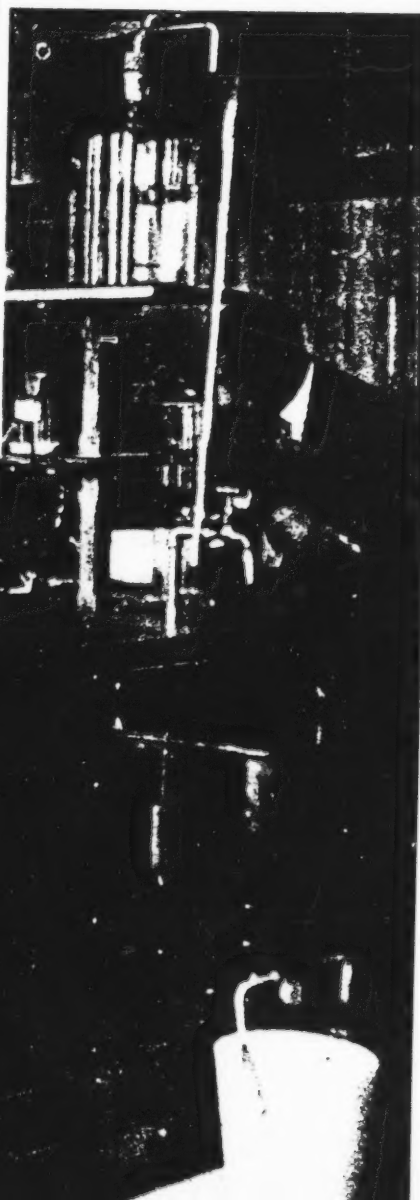
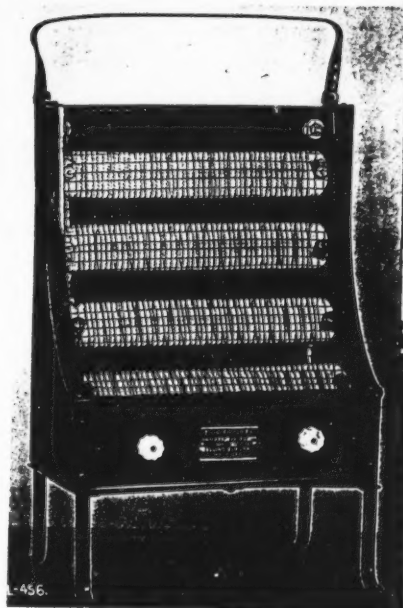
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(top left) The first step towards organizing a testing department within Ontario Hydro was taken in 1912, when H.D.G. Crerar set up a one-bench workshop in a corner of the basement of the former Toronto-Strachan Transformer Station. Mr. Crerar, seated in the middle of the lower step among a group of employees, was succeeded by W.P. Dobson, well-known at the time for his studies of transients due to high-voltage switching.

(top right) Portable electric heaters, furnace blowers and kitchen appliances were among a broad range of electrical products that since 1919 had come under close scrutiny of, and performance and safety testing by, Ontario Hydro's approvals laboratory before their certification for sale to the public. After reaching status as a national service, Ontario Hydro's approvals testing function was transferred to the Canadian Standards Association. The service continues to be a large part of CSA's activity.

(bottom) Considered to be one of the most advanced of its type anywhere, Ontario Hydro's structural materials laboratory, part of which is shown here as it appeared about 1920, has been used for all classes of physical testing and investigation of cements, aggregates and other concreting materials. By the end of the '20s, the laboratory had become internationally recognized for its development and use of scientific methods to assure quality of concrete used in construction of massive structures such as hydraulic dams and powerplant generator halls.



of the Commission. First delivery of power from the Ontario Power Company in Niagara Falls, Ontario, was in 1910 over transmission circuits constructed and owned by the Commission.

Since Ontario Hydro is not only an operating utility, but also largely designs and builds the necessary plant facilities, complex technical problems of a wide variety have arisen as the power system grew over the decades. In many instances the solutions have been based on work performed in the Research Division. This work in turn has produced basic improvements to materials and equipment, many becoming industry standards.

The need for utility-sponsored and utility-directed research in addition to manufacturer-sponsored programs has been shown by our experience to date. We have found that many areas of research and development can in fact only be carried out properly by a utility group. Much of the required research involves study of the power system as a whole rather than of the individual components. Typical examples range from studies of overhead-line vibration, environmental effects, system stability, and lightning and other weather-induced phenomena, to waste disposal and other nuclear-related problems and concerns. Most of the Division's growth in recent years has been needed to address such problems. In 1987 the number and complexity of problems, both current and foreseen, call for even more comprehensive interdisciplinary research programs than heretofore.

The Division's research programs are carried out by discipline-oriented electrical, mechanical, metallurgical, chemical and civil research departments, and by project-oriented teams for larger multi-disciplinary investigations. An operations research group performs studies of corporate-wide interest. Advice and guidance from Ontario Hydro's operating, engineering and marketing divisions are



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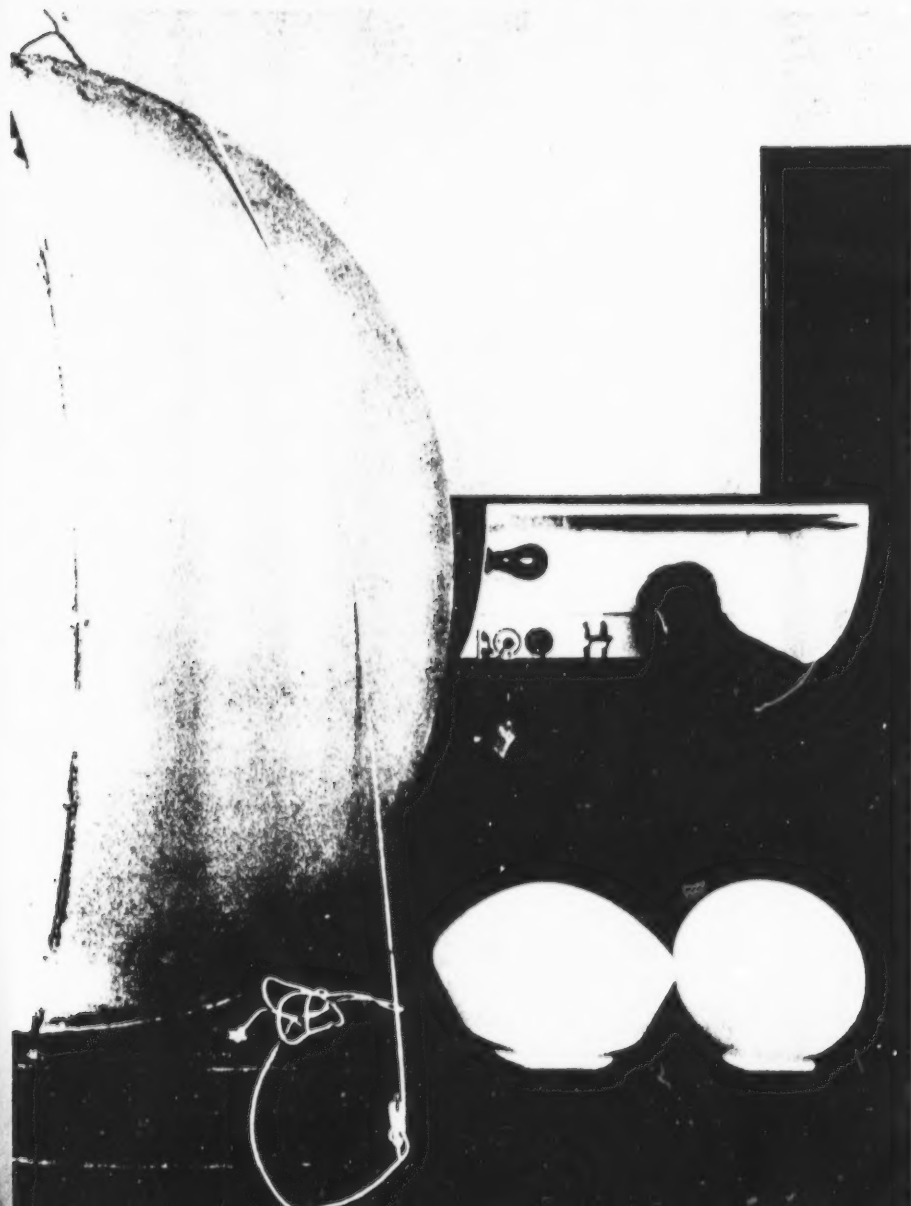


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used by standing research advisory committees in planning for future research.

Following a few historical notes, brief descriptions are given of the administrative structure, the general functions and the evolution of facilities of the Division. A description is also given of some significant current activities. Significant events and achievements over the years are represented by selected period photographs that supplement the text.

FROM BEGINNINGS TO PRESENT

Ontario Hydro's research and testing activities had their beginnings in 1912, in the basement of the former Toronto Strachan Transformer Station. As with early construction activities of Ontario Hydro, research and testing began on a small scale. The initial staff of three men began to work on problems of electrical standards and metering and of electric lamp testing and standards. In the following year, the staff of the Testing and Research Department (now the Research Division) was increased to five to enable high-voltage and other electrical testing to be performed. At that time the staff was transferred to a new building constructed next to the transformer station, which, with some additions, housed the research and testing work until late 1961.

As work at the Strachan Avenue laboratories expanded, the organization was divided into four sections: High Tension and General Testing, Standards and Meters, Lamps and Illuminating Engineering, and the Approvals Laboratory.

While the principal function of the laboratories was general testing and research, another important one was undertaken in 1919 – the testing of electrical materials, appliances and other equipment for safety from fire and accident. This service was undertaken because of Ontario Hydro's responsibility for the inspection of all electrical installations in Ontario.





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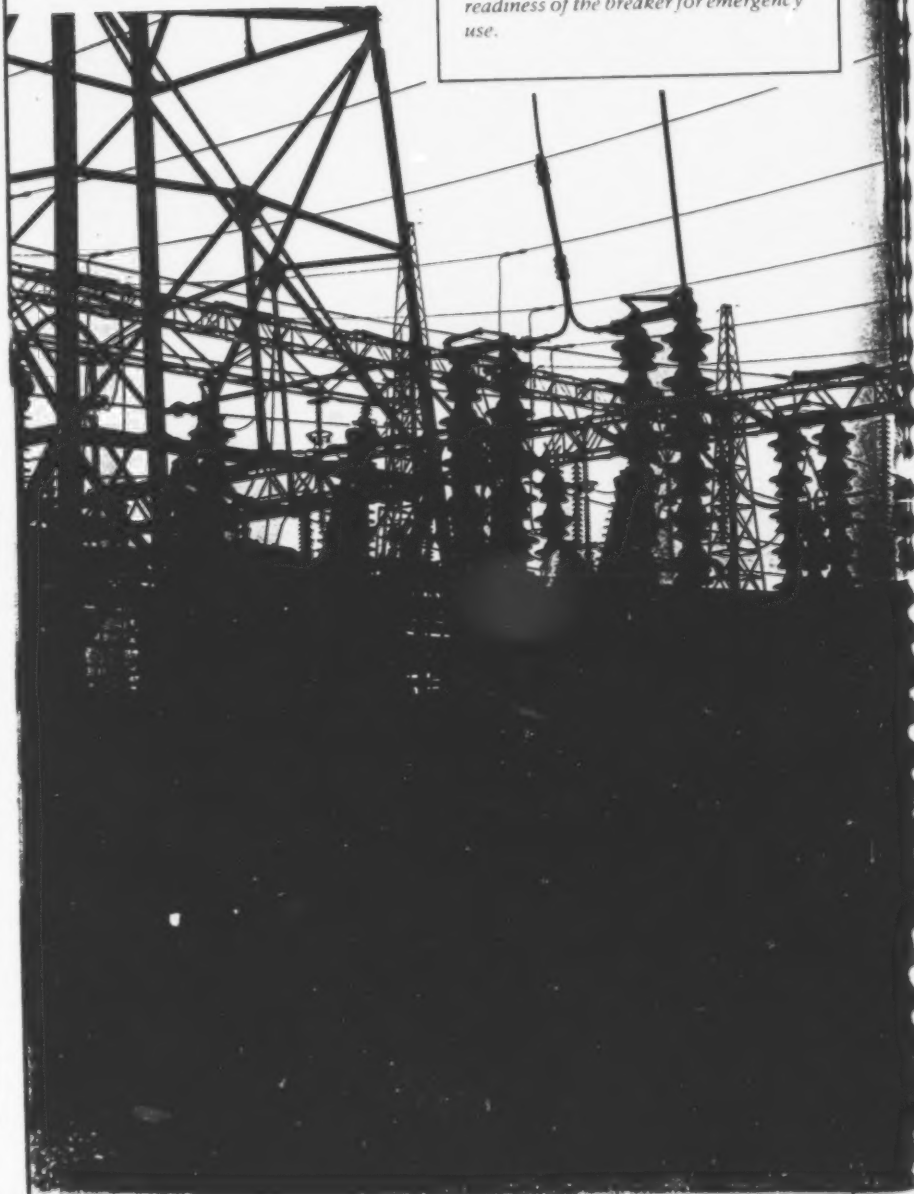
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(top left) The petrographer shown here, in the mid-'50s, records her findings after observation of the characteristics and identification of the constituents of a thin specimen of rock through a stereographic microscope. Recommendations of the petrographer largely determine the quality and ultimate endurance of the structure.

(top right) Here, in the '40s, a technician in the electrical standards laboratory calibrates portable standard wattmeters for use in field measurements, against precise laboratory-standard wattmeters.

(bottom) "Waltzing Matilda", the Research Division's mobile high-voltage laboratory of second-world-war vintage, contributed greatly to research in the '50s and '60s on the performance characteristics of apparatus insulation under field operating conditions. Here, "she" is subjecting a spare standby circuit breaker at a transformer station to an insulation power-factor test to ensure readiness of the breaker for emergency use.





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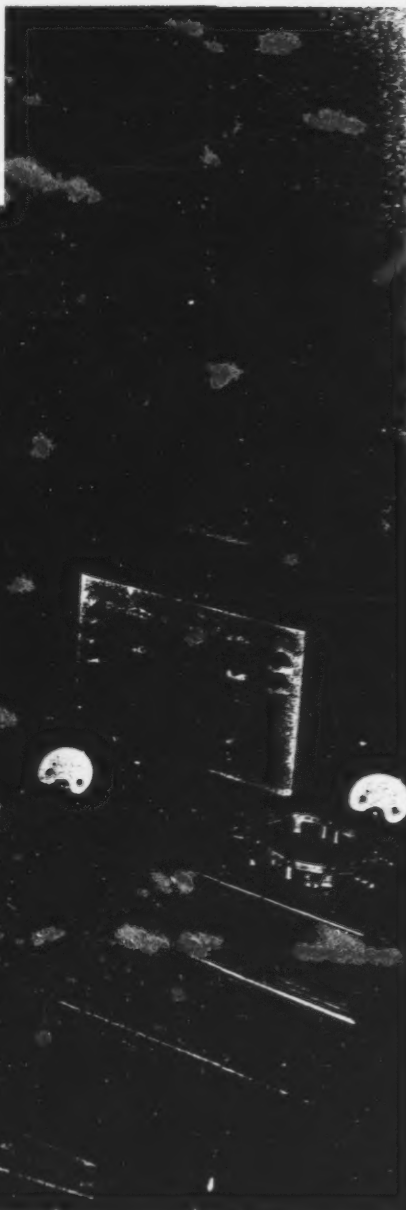
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(top left) In the '30s, Ontario Hydro launched a campaign to promote good lighting in industry and commerce and in the home. A visual display demonstrates the brightness of "Hydro long-life lamps". These lamps were manufactured to specifications developed by the illuminating section to provide service lives of at least 1,500 hours.

(top right) Over the years, safety in the workplace has been of prime concern to Ontario Hydro. Here, in about 1935, a technician evaluates the efficacy of a respirator designed for use in dusty or otherwise noxious atmospheres. Comparison-testing of various types of breathing apparatus continues to this day.

(bottom) Ontario Hydro was one of the first power utilities to recognize the role of electronic devices in the operation of a large power system. Among the many devices developed were the linascope for locating faults on transmission and communication circuits, the soniscope for ultrasonically examining the quality of concrete structures and the bolometer for measuring remotely the operating temperature of joints in transmission-line conductors.

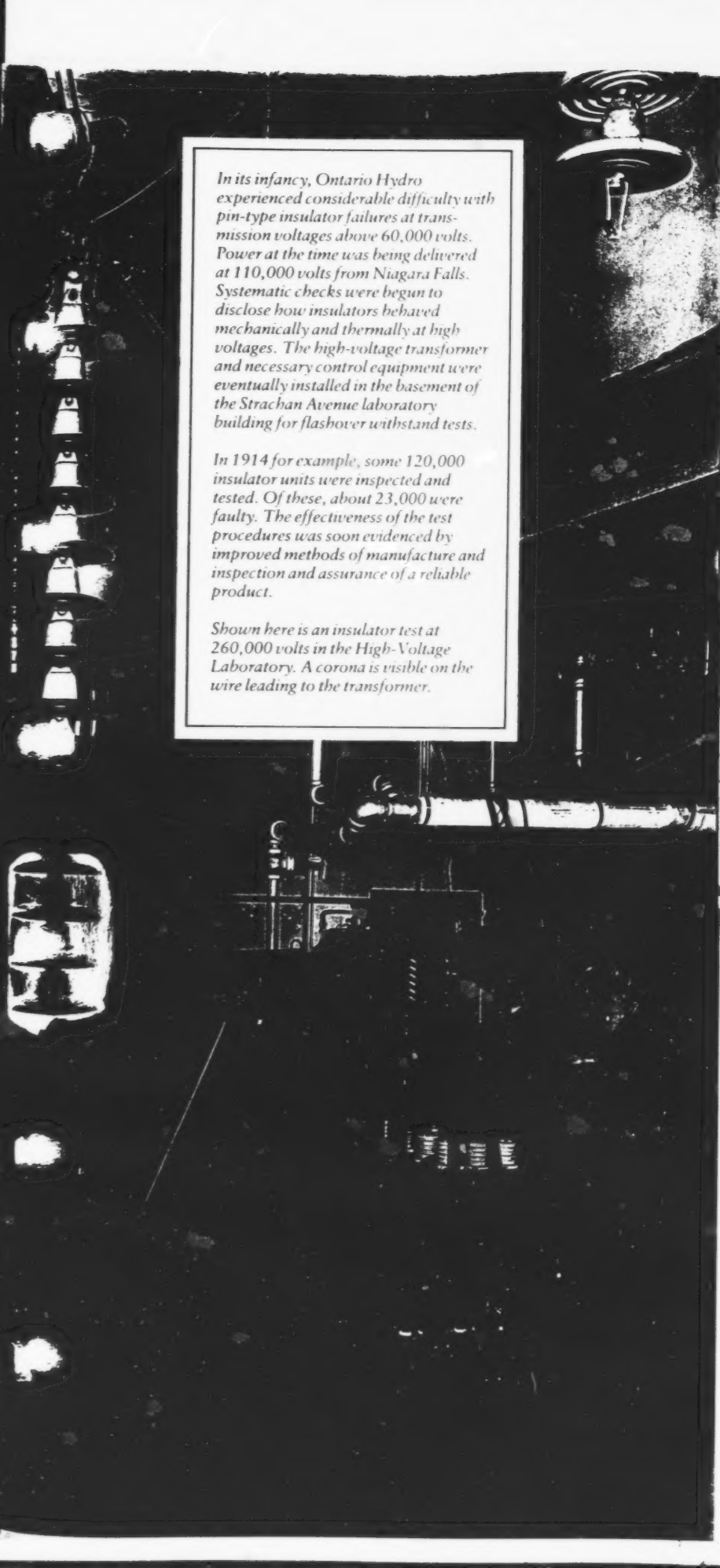


The service marked the beginning of electrical approvals and safety testing in Canada. From 1919, it gradually extended to other provinces and ultimately became a national service. In 1950 it was turned over to the Canadian Standards Association.

In 1930, director of research Mr. Dobson said, "In order that the laboratory may be posted on various aspects of testing and research, its members must have special knowledge. This is obtained either by research work and study, or by contact with other engineers engaged in similar work. The most satisfactory way of obtaining progress is by membership on standardizing and other technical committees." Mr. Dobson encouraged his staff to attach themselves to various technical organizations. The laboratory therefore became represented on committees of such bodies as the American Society for Testing Materials, the Canadian Engineering Standards Association, the American Institute of Electrical Engineers, the National Research Council, and the American Concrete Institute.

After 1930, Mr. Dobson continued to direct his organizational ability to strengthen research assistance to Ontario Hydro operating and engineering divisions and to the municipal utilities. He encouraged research staff to embark on new phases of inspection and testing. His keen interest in the basic sciences was used to encourage full use of the facilities of the laboratory.

By the late 50's, because of the increasing volume of work and of changing requirements, the need for more space and better accommodation for the Research Division had become urgent. With abandonment of the Strachan Avenue building required because of its location on the proposed route of a major expressway, plans for the present building on Kipling Avenue were begun in 1959. Construction was started in April, 1960, and the building was occupied in September, 1961.



In its infancy, Ontario Hydro experienced considerable difficulty with pin-type insulator failures at transmission voltages above 60,000 volts. Power at the time was being delivered at 110,000 volts from Niagara Falls. Systematic checks were begun to disclose how insulators behaved mechanically and thermally at high voltages. The high-voltage transformer and necessary control equipment were eventually installed in the basement of the Strachan Avenue laboratory building for flashover withstand tests.

In 1914 for example, some 120,000 insulator units were inspected and tested. Of these, about 23,000 were faulty. The effectiveness of the test procedures was soon evidenced by improved methods of manufacture and inspection and assurance of a reliable product.

Shown here is an insulator test at 260,000 volts in the High-Voltage Laboratory. A corona is visible on the wire leading to the transformer.

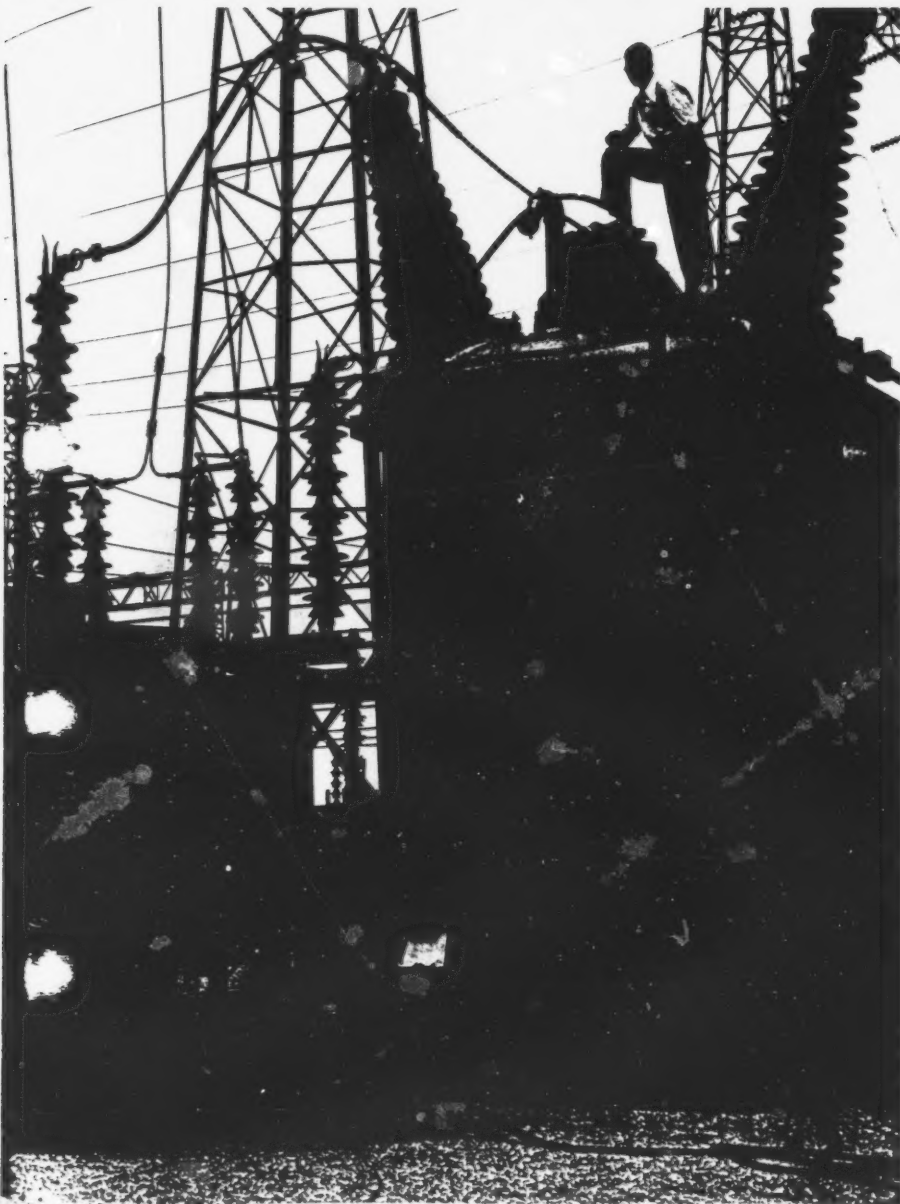
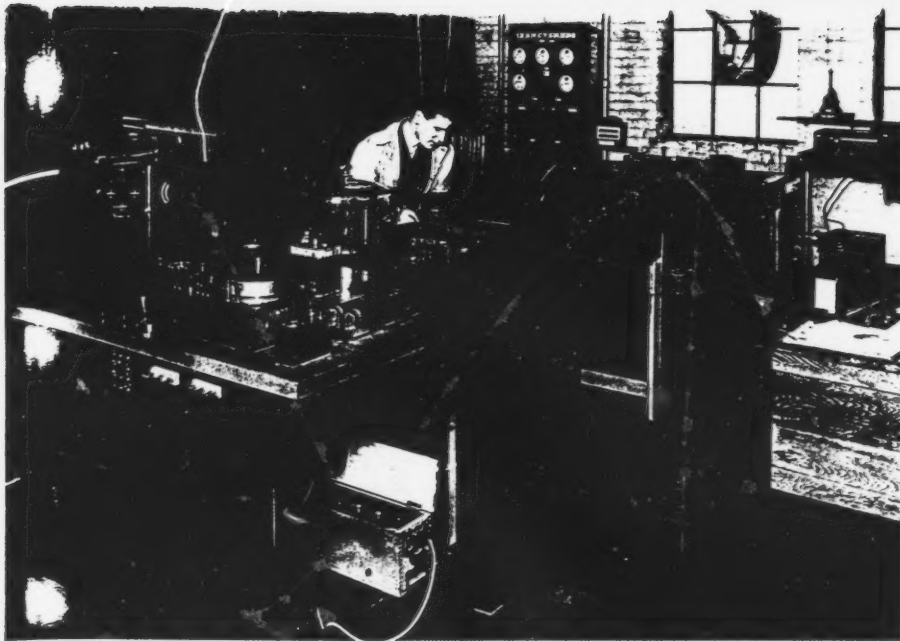


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Since then the main Kipling Avenue building has been supplemented by adjacent buildings used for biological, atmospheric and electrotechnologies research, testing of nuclear-process components, high-voltage and high-current research and testing, mechanical testing and development and other specialized purposes. The Research Division now has altogether about 35,000 square metres of office and laboratory space.

An outdoor laboratory at Kleinburg, about 30 kilometres north of the main laboratory, provides for electrical and mechanical testing of full-scale transmission structures and equipment.

ADMINISTRATIVE ORGANIZATION - THEN AND NOW!

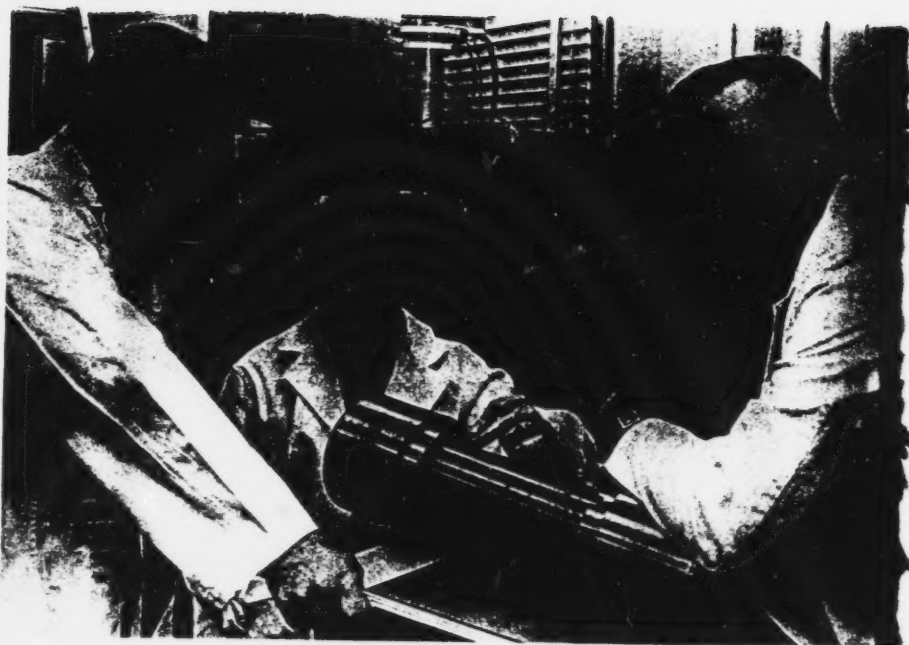
In its early days, the Division was directed by the Chief Testing Engineer with the advice of a Research Committee consisting of himself and the department heads. Subcommittees were appointed to oversee specific areas of research. Today, a similar system exists. The division is managed by the Director of Research with advice from an executive committee of managers. This committee develops research strategy using input from Research Program Advisory Committees of senior researchers appointed to recommend future programs.

Also in place is a technical ladder whereby scientific and engineering experts pursue anticipatory research unencumbered by administrative studies.

Thus the Division's organization is designed and the work coordinated to meet the constantly changing needs of all phases of Ontario Hydro's technical operations.

IN CONCLUSION

Over the past eight decades, Ontario Hydro has pioneered in many ways in the electric utility field. Seventy-five

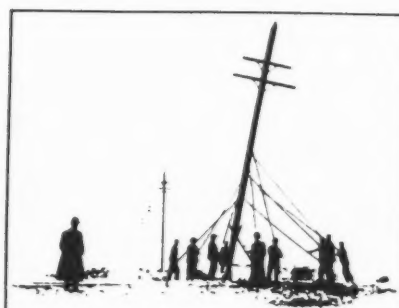


(top left) Work in the area of nuclear technology involves development of nondestructive on-line techniques and inspection devices for testing of the structural integrity of pressure tubes and other internal reactor components. Here, research staff display a test piece and, in the background, automated ultrasonic equipment, used to appraise various designs of experimental rolled joints at the interface between reactor pressure tubes and the reactor tubesheet.

(top right) In the '60s, a grounded cage surrounding a short length of overhead-line conductor made possible the study of corona phenomena in the laboratory at voltages much lower than actual line operating voltages. This and other test arrangements aided considerably in the development of methods for limiting radio and television interference (noise) from the power system.

(bottom) In 1919, Dr. W.P. Dobson was appointed to the Canadian Electrical Code Subcommittee. At that time the Committees, formed within the jurisdiction of the Canadian Engineering Standards Association (now Canadian Standards Association), were attempting to formulate rules and regulations regarding the inspection and installation of electrical equipment. To him can be attributed a great measure of initiative and success in the development of the Canadian Electrical Code, Parts I and II, and in the inauguration and steady progress of the CSA Approvals Service.

Dr. Dobson continued his interest in the Approvals Laboratories and provided technical guidance in numerous topics for 35 years. The Approvals Laboratories were completely divorced from Ontario Hydro in 1950. Dr. Dobson was honoured by being asked to turn the first sod of the new CSA Approvals Laboratory building aboard a caterpillar tractor on February 23, 1954.



years of related research has contributed to many technical advances.

Much valuable research has been and is, of course, conducted by manufacturers, and in university and other laboratories. The research group of an electric utility such as Ontario Hydro has the advantage, however, of an intimate knowledge of problems that arise in the day-to-day operation of a power system. This aids materially in achieving practical solutions and in confirming their adequacy.

The Research Division now spends about \$60 million on research and development annually. In recent decades, a large part of annual expenditures has been for studies related to the security, efficiency and environmental impact of the Corporation's nuclear generating stations which supply an increasing proportion of Ontario's demand for electricity. Major areas of research are concerned with the safe handling, storage and disposal of nuclear wastes, the integrity and dimensional stability of CANDU reactor fuel channels, the causes and control of corrosion and wear, the development of improved inspection techniques, and the decontamination of nuclear reactor systems. Work is continuing in support of the recently constructed tritium removal facility at Darlington nuclear generating station and of development of tritium technology for the Canadian Fusion Fuels Technology Program.

Other research deals with new and improved electrotechnologies for efficient use of electricity. Techniques are being developed that will permit more effective use of generating units, transmission lines, underground cables and interconnections with other systems. New developments also include upgrading of the capabilities of transmission lines and substations and automation of the distribution system.

Research continues into the formation of acid rain and development of measures for the control of acidic emissions from coal-fired generating



stations. Systems for the diversion of fish to avoid blocking of generating station water intakes are being developed, tested and implemented. A process developed for treatment of PCB-contaminated insulating oil and its restoration to oil of reusable quality has been successfully demonstrated to regulatory authorities and put into service.

In most projects, Ontario Hydro cooperates closely with other electric utilities, the Canadian Electrical Association, the Electric Power Research Institute in the United States, and manufacturers of equipment and materials. About 10 percent of the Research Division's effort currently is funded through contracts with these and other external agencies. The results often lead to transfer of technical expertise to the manufacturing sector.

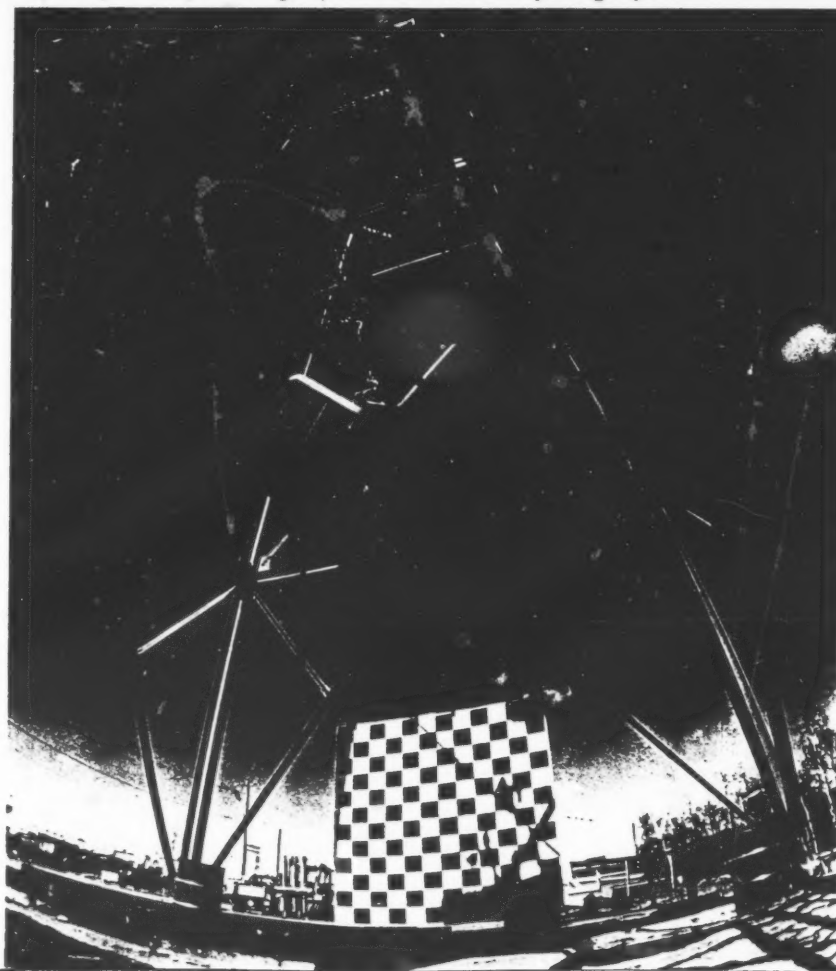
With continuing growth in the use of electricity and increasing technological and social demands, a challenge of immense proportions faces Ontario Hydro in the years ahead. As in the past, the Research Division's aim for the future will be to continue to provide technical services of the highest possible standard. Hydro's research, furthered by modern laboratory facilities, will assist substantially in providing a dependable and economical supply of electric power to users throughout the province.



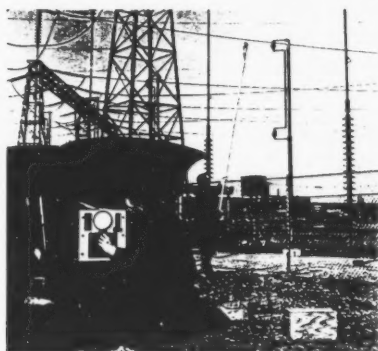
The technology available for analysis of materials has advanced phenomenally from the '50s to the present. Today, elemental composition analyses and high-resolution imaging of materials in support of metallographic, biological, geological, and other studies, are performed on a scanning electron microscope supplemented by an x-ray diffraction analyzer.

Much of the Research Division's nuclear work involves the study of means for safe handling, interim storage and permanent disposal of irradiated materials produced during the course of operation of Ontario Hydro's nuclear generating stations.

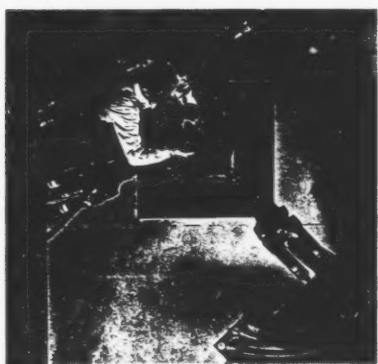
Here, at the Chalk River Nuclear Laboratories of Atomic Energy Canada Limited, the integrity of a stainless steel container for transportation of irradiated fuel was demonstrated in a free-fall drop test of the cask from a height of nine metres onto an unyielding surface.



Some Significant Research Contributions Over The Past 75 Years



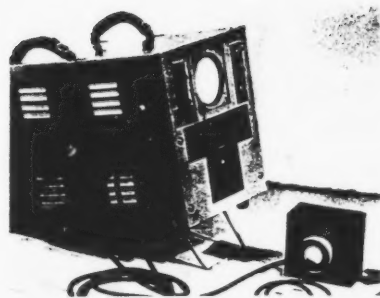
The Linascope – a device developed to locate faults in transmission and communication circuits.



The tri-axial shaker – an instrument developed to seismically qualify small- and medium-size nuclear equipment.



Flyash Utilization – an early leader in the application of flyash as a pumping aid in the placement of concrete at Ontario Hydro's nuclear sites.



The Soniscope – an ultrasonic device developed to measure deterioration and cracking in concrete.



The Coronaphone – a device designed to locate sources of radio interference due to corona discharge on high-voltage lines.



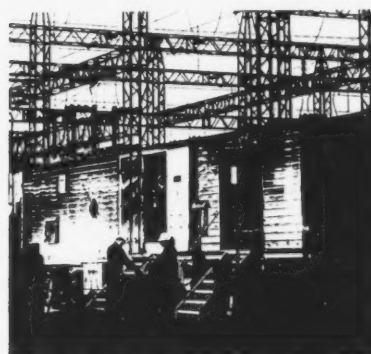
Monitoring for Predictive Maintenance – a computer-managed system developed for use in planning hydraulic generator maintenance.



ASIC – an Application Specific Integrated Circuit chip developed to replace existing digital circuits or to be used in new applications with specific requirements.



The Bolometer – an infrared instrument developed to detect overheated transmission line joints.



The Mobile Processing Unit – an oil processing facility designed to destroy low-levels of polychlorinated biphenyls (PCBs) in insulating oils safely and effectively.



CIGAR – a Channel Inspection and Gauging Apparatus developed to measure the dimensions and evaluate the integrity of pressure tubes in the fuel channels of CANDU reactors.